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Instruction for making
forest surveys and maps. Rev.

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

HENRY S. GRAVES, FORESTER

INSTRUCTIONS FOR MAKING FOREST SURVEYS AND MAPS

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U. S. DEPARTMENT OF AGRICULTURE,
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INSTRUCTIONS FOR MAKING FOREST SURVEYS AND MAPS.

ELEMENTS OF SURVEYING AND MAPPING.

These simple instructions are issued to members of the Forest Service in order that forest surveys and maps may be as nearly uniform as practicable. They do not include directions for the use of instruments of great precision, and the tables are prepared only to such accuracy as is attained in careful timber cruising or in surveying with the magnetic compass. This is $\frac{1}{4}°$ or 15′ of arc.[1]

Forest surveys are made for two purposes—to locate and mark lines or boundaries upon the ground, or to furnish data for the preparation of maps.

The correctness of a survey depends upon the excellence of the instruments in use and the skill of the surveyor and his party. A skillful surveyor can do better work with poor instruments than an unskilled or careless one with the best instruments. Small instrumental

[1] The "diurnal" or daily change of a magnetic needle, which is one of the variations for which allowance is made in precise surveying, amounts to 10′ or 15′, and the influence of magnetic storms upon the needle is frequently unsuspected at the time a survey is made.

Clinometers and clinometer compasses, by which the degree of a slope or a vertical angle may be measured, are generally read only to the nearest $\frac{1}{2}°$ or $\frac{1}{4}°$.

Members of the Forest Service who are using solars, transits, levels, etc., have received training and experience in the care and use of such instruments, and can execute the necessary surveys of precision. They are provided with advanced manuals of surveying and construction, tables, ephemerides, etc.

errors usually balance themselves, and they are quickly discovered by the trained operator, who will know how to make allowance for them, if necessary. The unskilled or careless man will sometimes read the wrong end of the compass needle; read the graduated ring dial from the wrong direction; make a mistake in entering the reading in his notebook, or perpetrate some other palpable blunder which will throw doubt over the whole work and make a resurvey necessary.

Certain fundamental principles underlie all surveys. We may assume a piece of land the location, extent, and contour of which are unknown. First of all the survey should determine its location, shape, and area, and if necessary its topography, and any other essential data. As in logic, one should start from something which is known to determine something which is unknown. The line which connects an unknown point with a known point is called a *tie*, and as soon as the tie is run the position of the unknown point is established. A line run around a tract of land is called a *boundary line*, and the angles on this line are called corners, stations, posts, or stakes, according to the local or established terms. It is not always necessary to run the boundaries of a tract to determine its position and area. A base line might be run across it with ordinates on either side extending to the limits of the tract. Or if the tract is a small watershed, lines might be traversed up all of the streams and drainage lines, or the area might be divided into squares and fractions of squares, similar to land-survey sections. Still another way will be described under the head of "Plane table."

The method to be employed depends upon the purpose of the survey, but no matter what method is used, the survey will fail in its primary purpose if it does not show the location, position, form, and size of the tract surveyed.

INSTRUMENTS USED.

Three kinds of instruments are used in surveying, viz: For determining *azimuth* or horizontal angles; for determining grade or *vertical angles;* for determining *distances*. The horizontal deflection of a line is always expressed in *degrees*. The vertical deflection of a line is generally expressed in *per cent*. The length of a line in Government land surveying is always expressed in *chains* (66 feet). The *altitude* above sea level is expressed in *feet*.

The principal instrument for determining azimuth is the magnetic compass, which, although of very simple construction, will be absolutely misleading to anyone who uses it without understanding. Suppose, for instance, a good compass, manufactured and adjusted in some eastern factory or in Europe, should be taken to the Pacific coast. It would undoubtedly indicate the direction of the magnetic currents at any time and place that it might be used, but its needle would not point north and south and probably would not hang level on the center pivot. The latter defect is quickly remedied by moving a little sliding weight, which should be on the south end of the needle.

Sight compasses are constructed so that they may be sighted upon a distant object and the magnetic direction is determined by reading the degree indicated on the ring dial by the north end of the needle.

Vernier compasses are provided with a revolving graduated ring dial which may be set according to the magnetic variation, thus reducing the reading to true north instead of magnetic north.

Clinometer compasses are provided with a small pendulum hung from the center pivot, which is used to determine a vertical angle.

Prismatic compasses are sight compasses with a "floating" dial which may be held in the hand. The sight is taken and the direction is read in the same operation.

Mirror compasses are provided with a reflecting surface on the inside of a hinged cover, and the reflection of the reading is noted at the time the sight is taken.

Alidade compasses are provided with at least one straight edge parallel to the line of sight. The bottom of the compass is smooth so that the instrument may be laid upon a map and the straight edge used as a ruler.

Solar compasses are provided with a special attachment which can be revolved independent of the compass for taking observations on the sun and determining the cardinal direction without using the compass needle.

Compasses are also used as a part of the equipment of transits, levels, and plane tables, and in such cases these instruments should be constructed of nonmagnetic materials, in order that the needle may not be deflected. Iron, nickel, cobalt, and manganese are the most magnetic substances.

The instruments for determining grade or vertical angles are:

The grademeter;

The Locke hand level; and

The Abney reflecting level, which is provided with a vertical arc, graduated either to per cent, degrees, or ratio of slope, according to the purpose for which it is used.

The unit of land measure is the standard surveyor's chain of 66 feet. For some classes of work steel band chains or steel tapes are found more convenient and economical, because they are lighter and greater lengths can be dragged over the ground, thus effecting a saving in pinning and tallying. Tapes are usually graduated in feet, and when they are used it is necessary to reduce the measurements to standard chains, in order that they may conform with the official land surveys. In some regions the best means for determining distances are the stadia transit and rod. These instruments are used by specially trained men, and are therefore not described here.

FOREST SERVICE STANDARD COMPASS.

Figure 1 shows the surveying compass which has been adopted by the Forest Service for the use of field men in making forest surveys and maps. Very accurate work can be done with this instrument if properly used, and for this reason requisitions for transits should not be made unless there is a special need for using a still higher grade instrument. The principal features of this standard compass are as follows:

The sights are very tall, and therefore admit of use on steep hillsides or in taking observations on Polaris. The hair sight may be repaired easily by threading through the holes at *A* and *B*. If after long use the

sights work too freely they may be tightened by the nut *C*.

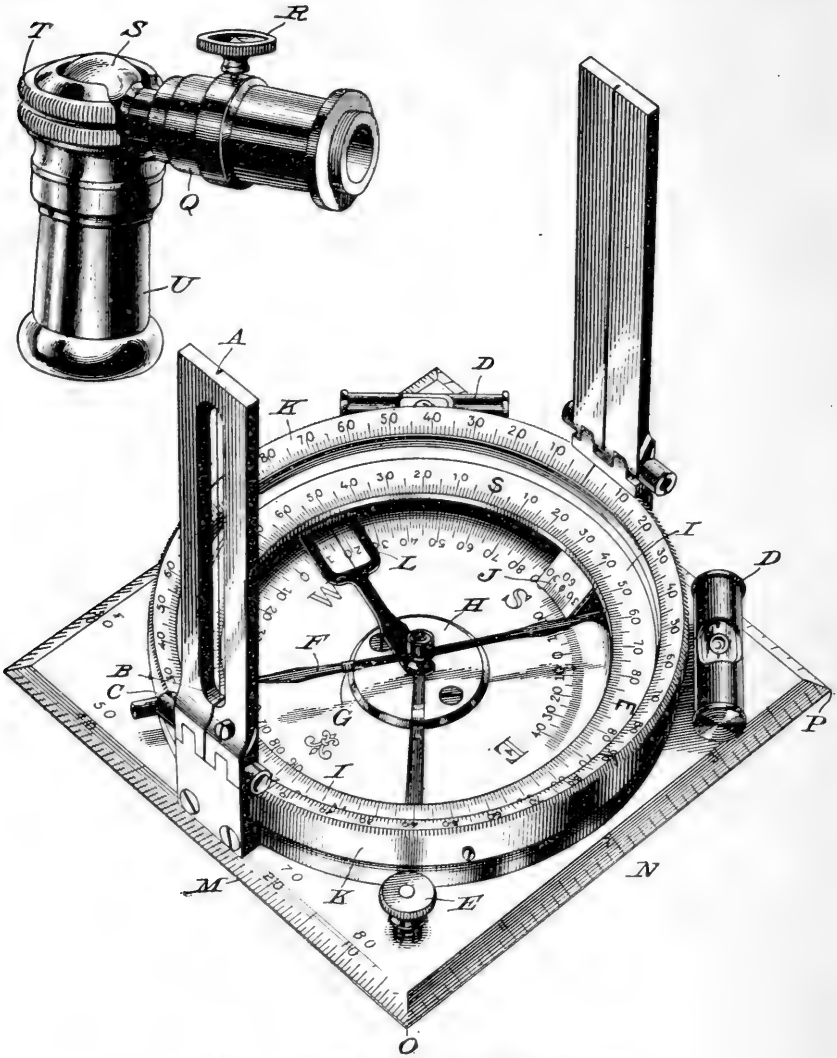


FIG. 1.—Forest Service standard compass.

The base of the instrument is an accurate square, beveled and graduated as a protractor on two sides

and to inch scales on two sides. One of these scales is Forest Atlas standard of 1 inch to 1 mile, and is divided into eighths, each of which represents 10 chains. The other scale is decimal. The base supports two levels, *D*, set at right angles to each other, each being adjustable by means of small screws and a center point on which they rock.

The clamp *E* is a milled nut which operates to lift the needle from the center pin when the compass is not in use. It works so easily on a screw that the azimuth of the instrument need not be disturbed when the needle is unclamped or clamped. The thread is riveted on the top so that the nut will not come off and be lost.

The needle *F* is of blue steel and is provided on its south end with a small brass weight, which may be pushed toward or away from the center if it becomes necessary to make the needle hang horizontal and counteract the magnetic dip in any locality. Of course the needle should be removed from the center pivot when this is done. The base dial is reenforced at *H* to hold the center pivot more securely. It is engraved to show (1) the cardinals, (2) a half circle of degrees for the clinometer, and (3) 70° of variation, including east and west. The ring dial *I* is graduated to degrees reading from zero°, from north and south, to 90° at east and west. It carriers a vernier, *J*, which reads against the variation graduation on the base dial. The cover is of heavy plate glass and is held in place by a graduated and slotted rim, *K*, which also revolves in azimuth.

The clinometer consists of a weighted pendulum, *L*, which hangs on the center pivots and is provided with

a pointer which reads against a graduation on the base dial.

The edges *M* and *N* are perpendicular to each other, and the line *O P* is parallel to the line of sight and may, therefore, be used as an alidade.

The above description covers that portion of the instrument which is used upon a plane table either for ordinary compass work or for mapping on the plane-table sheet. The instrument is, however, provided with a ball-and-socket attachment so that it may be used upon a Jacob staff, tripod, or more conveniently held in the hand if used as a hand compass for rough cruising. These parts are shown in the illustration; *Q*, a cone-bearing containing the spindle, which may be clamped by the screw *R;* the ball *S* is held by the socket cover *T*, which screws upon the mounting *U*.

When this instrument is used on the plane table the proceeding is as follows:

The sights having been raised and the instrument laid on the table, the table is leveled by observing the bubbles. The variation having been set off, the table is oriented with the compass needle, which should read zero at the north end. Then sights may be taken upon all the objects to be mapped, using the edge *O P*, or the opposite parallel edge, as an alidade. The distances may be measured with the scale.

When used as a surveyor's compass the leveling is done by means of the ball and socket *S* and *T*, and the compass is revolved in azimuth by loosening the clamp screw *R*.

As a clinometer for measuring vertical angles, the edge *M* may be laid upon a slope and the pendulum

will show the number of degrees of dip or rise. This is not the same as "per cent of grade." The difference is shown on page 40. Another method is to lay the edge *M* on the level plane-table board and, revolving the rim vertically, take a sight through the slots *K*. The angle of dip or rise may then be very closely approximated by reading the graduation on the rim. In some of these instruments the cover of the socket, at the ball joint, is cut away on one side, permitting the spindle to be tipped over and the compass revolved in a vertical plane. The sights may then be used in connection with the clinometer. This altered socket will be issued when specially requisitioned.

Right angles may be turned accurately without the use of the compass by two methods: (1) By drawing a line on the plane-table sheet on the edges *O P* and then turning the instrument 90° until the edge *M* coincides with the line, or (2) the slots *K* may be used without moving the instrument, as they are placed exactly 90° apart.

This instrument should give good results if used and treated with the care which is necessary for any well-made and carefully adjusted instrument. The custodian should keep it clean, but should not oil it, though it may be wiped occasionally with a slightly greasy piece of muslin. The needle should always be clamped when not in use, and the hair sight should always be closed down first so that it will be protected by the slot sight. The cover glass may be removed by taking off the sights and then the surrounding rim, which is provided with small brass screws which travel in a channel cut into the outside of the compass box. It is

not necessary to remove the glass in order to sharpen the center pivot. This may be done by unscrewing it from the under side of the compass after the needle has been clamped, although this must be done very carefully, so that the clinometer pendulum will not move out of place; otherwise it will be necessary to remove the cover glass.

In case of any serious injury to any instrument, it should be returned to the property clerk at Ogden for repairs.

The instrument should not be kept near large bodies of iron, nor exposed to electric motors or generators. Compass needles are frequently demagnetized by being carried in a valise in an electric car and being set down over a powerful motor, because the needle is clamped (as it should be) while being carried. On the other hand, the magnetism of a needle may be strengthened by laying the compass, with the needle unclamped, near a direct-current motor or generator or strong magnet. A better plan is to unclamp the needle, and after it has found its bearing, to clamp it and leave it to the influence of the magnetic current. In this way the continued quiver of the needle will not dull the center pivot.

Do not allow the needle to be deflected, while being read, by an ax, jackknife, pencil tip, the metal band of a hat, or other metal.

THE POCKET COMPASS.

The Forest Service standard pocket compass is a strong and serviceable instrument for cruising or retracing survey lines. Instructions for its proper use are engraved upon the base dial, as shown in figure 2.

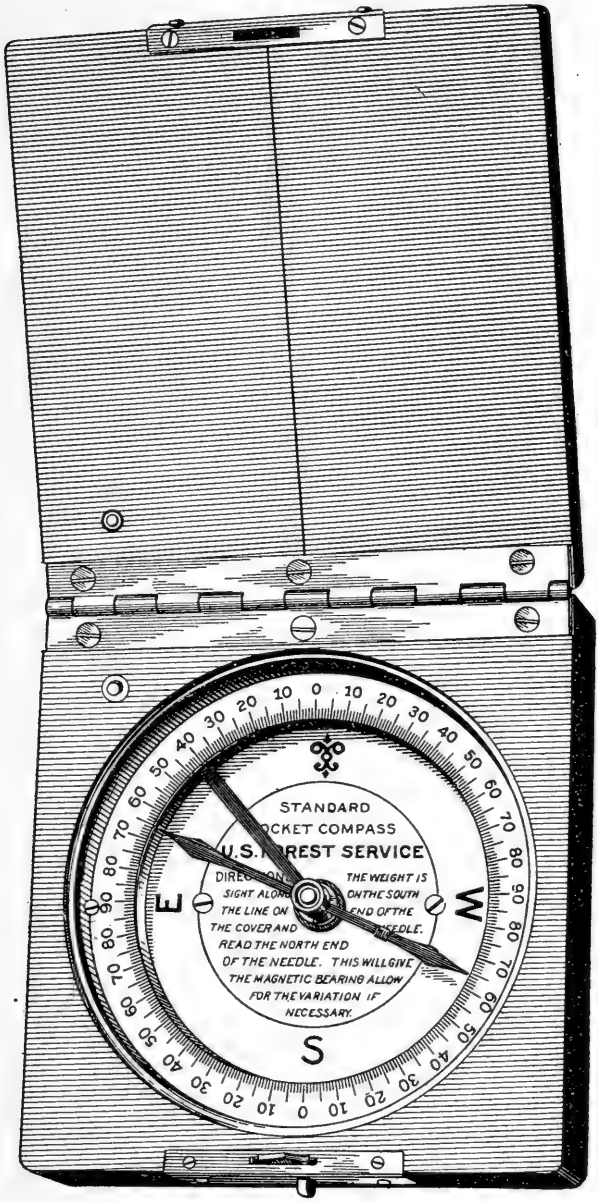


FIG. 2.—Standard pocket compass.

MAGNETIC NEEDLE.

It is unfortunate that all makers of surveying instruments do not have a uniform method of designating the north or south end of compass needles, but that the surveyor must learn and remember whether the blue or white, or the weighted or cross-barred end of the needle is the one which points northward. Some small compasses also differ in the positions of the E. and W. according to the use which is to be made of them. If they are to be used as sight compasses, they should have the E. on the left side of the dial. In good weather, when the sun shines or where distant features of the landscape are in constant view, there is little chance of error by reading the wrong end of the needle, but there are many conditions under which the compass alone must be the guide.

VARIATION.

It will be seen by the map (fig. 3) that only along one line in the United States, the so-called "line of no variation," does the needle point due north. This line is not stationary, but has a slow movement westward. At all other points in the United States the north end of the needle is deflected toward the "line of no variation." In the North Atlantic States the variation of the north end of the needle is to the west, and a surveyor at Augusta, Me., would enter in his field notes "variation 16° west." At Portland, Oreg., the entry would be "variation 21½° east." The maximum annual change of variation in the United States is only about 5 minutes. On the Pacific coast it is only 1 minute.

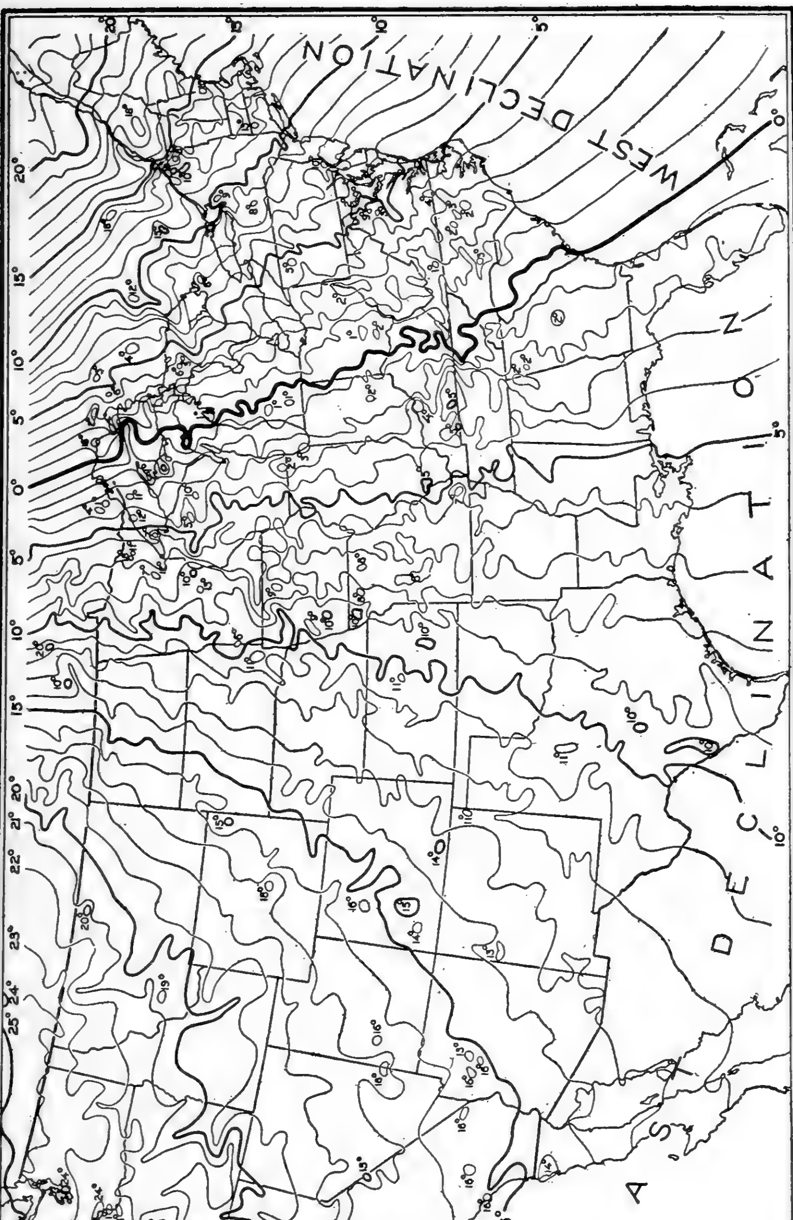


FIG. 3.—Lines of equal magnetic variation in the United States. West of the heavy line the variation is east of true north. East of the heavy line the variation is west of true north.

If a survey is to be made in a region which has not been subdivided by Government land surveys or where the variation of the needle is not known, then the surveyor must do one of three things. He should if possible find the variation by observing the Pole Star, of which approximate bearings are given (Table 1) at 9 p. m. during the year; or he may obtain the true meridian by observing the sun at apparent noon. If neither can be done, a variation may be assumed after examination of figure 3, and this assumed variation should be entered in the field notes and shown on the map, with the date when the map is prepared.

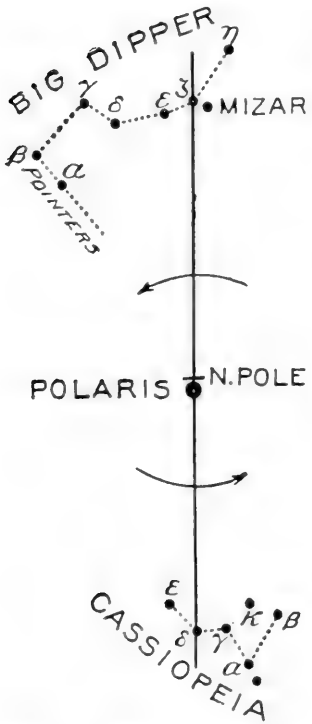


FIG. 4.—Position of the Big Dipper and Cassiopeia when Polaris is due north. If the figure is held upside down it shows the reverse position in which Polaris is also due north.

OBSERVING POLARIS.

The Pole Star is not exactly above the North Pole of the earth, but its bearing is due north twice a day, and an observation of it at one of these times will give a true meridian. Mizar, a double star in the bend of the handle of the Big Dipper is either above or below the Pole Star at these times. The same is true of the star δ (Delta) in the constellation Cassiopeia. (See fig. 4.) At all other hours the Pole Star has a bearing either

east or west of true north. It is most convenient to take a sight on Polaris at 9 p. m., and for this reason the accompanying table was prepared. The sight having been taken, it will be easy to turn the compass to true north and ascertain the variation.

TABLE 1.—*Bearing of Polaris, east or west of true north, at 9 p. m. at different latitudes in the United States for the years 1912, 1913, 1914.*

Date.		Latitude.										
		26°.	28°.	30°.	32°.	34°.	36°.	38°.	40°.	42°.	44°.	46°.	48°.
Jan.	1	¾° W.	¾° W.	¾° W.	¾° W.	¾° W.	¾° W.	¾° W.	½° W.	1 ° W.	1 ° W.	1 ° W.	1 ° W.
	15	1	1	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼
Feb.	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
	15	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1¾	1¾
Mar.	1	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1½	1¾	1¾
	15	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1¾
Apr.	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
	15	¾	1	1	1	1	1	1	1	1	1	1	1¼
May	1	½	½	½	½	¾	¾	¾	¾	¾	¾	¾	¾
	15	¼° W.	¼° W.	¼° W.	¼° W.	¼° W.	¼° W.	¼° W.	¼° W.	¼° W.	¼° W.	½° W.	¼° W.
June	1	North.											North.
	15	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	½° E.	½° E.
July	1	¾	¾	¾	¾	¾	¾	¾	¾	¾	¾	1	1
	15	1	1	1	1	1	1	1	1	1	1¼	1¼	1¼
Aug.	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½
	15	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1½	1½
Sept.	1	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1½	1¾	1¾
	15	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1¾
Oct.	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
	15	1	1	1	1	1	1	1	1	1	1	1¼	1¼
Nov.	1	½	½	½	½	¾	¾	¾	¾	¾	¾	¾	¾
	15	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼° E.	¼ E.	¼° E.
Dec.	1	North.											North.
	15	½° W.	½° W.	½° W.	½° W.	½° W.	½° W.	½° W.	½° W.	½° W.	½° W.	½° W.	½° W.

OBTAINING A TRUE MERIDIAN BY OBSERVING THE SUN AT APPARENT NOON.

In addition to the instructions given on pages 16 to 19, there is a method of obtaining a true meridian by observing the sun with a sight compass at the exact time it is due south. The time of this southing is called apparent noon and changes from day to day. It is not the same as local mean noon, nor standard time noon. It is best to set your watch for local mean time, since you can then observe a southing at the time given in Table 2. If your watch is set for standard time, it will be necessary to set it ahead or back by adding or subtracting a correction, according as the longitude of your station is either east or west of one of the standard meridians. These are:

Local mean time at—
Longitude 75°=Eastern standard time.
Longitude 90°=Central standard time.
Longitude 105°=Mountain standard time.
Longitude 120°=Pacific standard time.

The correction for a degree of longitude is 4 minutes of time; the correction for a minute of longitude is 4 seconds of time. To illustrate: The local mean time in longitude 108° will evidently be 12 minutes behind Mountain standard time, or 48 minutes ahead of Pacific standard time. The local mean time in longitude 114° 35′ will be 21 minutes and 40 seconds ahead of Pacific standard time. The method is:

Pacific standard time is for longitude	120° 00′
Local mean time is required for longitude	114° 35′
The difference in longitude is	5° 25′

Then	5°	25′
Multiplied by	4	4

Gives 20 m. 100 s., or 21 m. 40 s.

TABLE 2.—*Showing the hour, minute, and second at which the sun will bear exactly south. The watch must be set to local mean time (not standard, nor sidereal, nor sun time).*

FOR THE YEAR 1912, IN THE WESTERN UNITED STATES.

Day of month.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	H. m. s.	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*
1.....	12 3 23	12 13 41	12 12 30	12 3 54	11 57 0	11 57 38	12 3 38	12 6 8	11 59 52	11 49 37	11 43 39	11 49 12
2.....	12 3 51	12 13 50	12 12 17	12 3 36	11 56 53	11 57 47	12 3 49	12 6 4	11 59 33	11 49 18	11 43 38	11 49 35
3.....	12 4 19	12 13 57	12 12 4	12 3 18	11 56 46	11 57 56	12 4 0	12 5 59	11 59 14	11 48 59	11 43 38	11 49 58
4.....	12 4 47	12 14 3	12 11 51	12 3 1	11 56 40	11 58 6	12 4 11	12 5 54	11 58 54	11 48 41	11 43 39	11 50 22
5.....	12 5 14	12 14 9	12 11 38	12 2 43	11 56 35	11 58 17	12 4 21	12 5 48	11 58 34	11 48 23	11 43 40	11 50 47
6.....	12 5 41	12 14 14	12 11 24	12 2 26	11 56 30	11 58 27	12 4 31	12 5 42	11 58 14	11 48 5	11 43 43	11 51 13
7.....	12 6 7	12 14 18	12 11 9	12 2 8	11 56 25	11 58 38	12 4 41	12 5 35	11 57 54	11 47 48	11 43 46	11 51 39
8.....	12 6 33	12 14 21	12 10 54	12 1 51	11 56 22	11 58 50	12 4 51	12 5 27	11 57 34	11 47 31	11 43 50	11 52 5
9.....	12 6 59	12 14 23	12 10 39	12 1 35	11 56 19	11 59 1	12 5 0	12 5 19	11 57 13	11 47 15	11 43 55	11 52 32
10.....	12 7 24	12 14 25	12 10 23	12 1 18	11 56 16	11 59 13	12 5 9	12 5 11	11 56 53	11 46 59	11 44 1	11 52 59
11.....	12 7 48	12 14 26	12 10 7	12 1 2	11 56 14	11 59 25	12 5 17	12 5 2	11 56 32	11 46 44	11 44 8	11 53 27
12.....	12 8 12	12 14 26	12 9 51	12 0 46	11 56 13	11 59 37	12 5 25	12 4 52	11 56 11	11 46 29	11 44 15	11 53 55
13.....	12 8 35	12 14 25	12 9 35	12 0 31	11 56 12	11 59 50	12 5 32	12 4 41	11 55 50	11 46 15	11 44 24	11 54 24
14.....	12 8 58	12 14 24	12 9 18	12 0 16	11 56 12	12 0 2	12 5 39	12 4 30	11 55 29	11 46 1	11 44 33	11 54 53
15.....	12 9 20	12 14 22	12 9 1	12 0 1	11 56 12	12 0 15	12 5 45	12 4 19	11 55 8	11 45 48	11 44 43	11 55 22
16.....	12 9 42	12 14 19	12 8 44	11 59 46	11 56 13	12 0 28	12 5 51	12 4 7	11 54 46	11 45 35	11 44 54	11 55 51
17.....	12 10 2	12 14 16	12 8 27	11 59 32	11 56 14	12 0 41	12 5 56	12 3 55	11 54 25	11 45 23	11 45 6	11 56 20
18.....	12 10 22	12 14 11	12 8 10	11 59 18	11 56 16	12 0 54	12 6 1	12 3 42	11 54 4	11 45 11	11 45 18	11 56 50
19.....	12 10 42	12 14 7	12 7 52	11 59 5	11 56 19	12 1 7	12 6 6	12 3 28	11 53 43	11 45 0	11 45 31	11 57 19
20.....	12 11 0	12 14 1	12 7 34	11 58 52	11 56 22	12 1 20	12 6 9	12 3 14	11 53 22	11 44 49	11 45 46	11 57 49
21.....	12 11 18	12 13 55	12 7 16	11 58 40	11 56 26	12 1 33	12 6 12	12 2 59	11 53 0	11 44 40	11 46 1	11 58 19
22.....	12 11 35	12 13 48	12 6 58	11 58 28	11 56 30	12 1 46	12 6 15	12 2 44	11 52 39	11 44 31	11 46 16	11 58 49
23.....	12 11 51	12 13 40	12 6 39	11 58 16	11 56 35	12 1 59	12 6 17	12 2 29	11 52 18	11 44 22	11 46 33	11 59 19
24.....	12 12 7	12 13 32	12 6 21	11 58 5	11 56 40	12 2 12	12 6 18	12 2 13	11 51 58	11 44 14	11 46 50	11 59 49
25.....	12 12 22	12 13 23	12 6 3	11 57 54	11 56 45	12 2 25	12 6 19	12 1 57	11 51 37	11 44 7	11 47 8	12 0 18
26.....	12 12 35	12 13 13	12 5 45	11 57 44	11 56 51	12 2 37	12 6 19	12 1 40	11 51 16	11 44 1	11 47 27	12 0 48
27.....	12 12 48	12 13 3	12 5 26	11 57 34	11 56 58	12 2 49	12 6 19	12 1 23	11 50 56	11 43 55	11 47 46	12 1 18
28.....	12 13 1	12 12 53	12 5 8	11 57 25	11 57 5	12 3 2	12 6 18	12 1 6	11 50 36	11 43 50	11 48 6	12 1 47
29.....	12 13 12	12 12 41	12 4 49	11 57 16	11 57 13	12 3 14	12 6 16	12 0 48	11 50 16	11 43 46	11 48 27	12 2 16
30.....	12 13 23	.....	12 4 31	11 57 8	11 57 21	12 3 26	12 6 14	12 0 29	11 49 56	11 43 43	11 48 49	12 2 46
31.....	12 13 32	.....	12 4 13	.....	11 57 29	.....	12 6 11	12 0 11	.....	11 43 40	.....	12 3 14

TABLE 2a.—*Showing the hour, minute, and second at which the sun will bear exactly south. The watch must be set to local mean time (not standard, nor sidereal, nor sun time).*

FOR THE YEAR 1913 IN THE WESTERN UNITED STATES.

Day of month.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	H. m. s.	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*
1	12 3 43	12 13 47	12 12 32	12 3 58	11 57 1	11 57 35	12 3 34	12 6 9	11 59 58	11 49 43	11 43 41	11 49 7
2	12 4 11	12 13 54	12 12 20	12 3 40	11 56 54	11 57 44	12 3 46	12 6 6	11 59 39	11 49 24	11 43 40	11 49 30
3	12 4 39	12 14 1	12 12 7	12 3 22	11 56 47	11 57 54	12 3 57	12 6 1	11 59 20	11 49 5	11 43 39	11 49 54
4	12 5 7	12 14 7	12 11 54	12 3 4	11 56 41	11 58 4	12 4 8	12 5 56	11 59 1	11 48 47	11 43 40	11 50 18
5	12 5 34	12 14 12	12 11 41	12 2 47	11 56 36	11 58 14	12 4 19	12 5 51	11 58 41	11 48 29	11 43 41	11 50 42
6	12 6 1	12 14 16	12 11 27	12 2 30	11 56 31	11 58 25	12 4 29	12 5 45	11 58 21	11 48 11	11 43 43	11 51 7
7	12 6 27	12 14 20	12 11 13	12 2 13	11 56 27	11 58 36	12 4 39	12 5 38	11 58 1	11 47 54	11 43 46	11 51 33
8	12 6 53	12 14 23	12 10 58	12 1 56	11 56 23	11 58 47	12 4 49	12 5 30	11 57 41	11 47 37	11 43 50	11 52 0
9	12 7 18	12 14 25	12 10 43	12 1 39	11 56 20	11 58 59	12 4 58	12 5 22	11 57 20	11 47 21	11 43 55	11 52 26
10	12 7 42	12 14 26	12 10 28	12 1 22	11 56 17	11 59 11	12 5 7	12 5 14	11 56 59	11 47 5	11 44 1	11 52 53
11	12 8 6	12 14 26	12 10 12	12 1 6	11 56 15	11 59 23	12 5 15	12 5 5	11 56 38	11 46 49	11 44 7	11 53 21
12	12 8 30	12 14 26	12 9 56	12 0 50	11 56 13	11 59 35	12 5 23	12 4 55	11 56 17	11 46 34	11 44 14	11 53 49
13	12 8 53	12 14 25	12 9 40	12 0 35	11 56 12	11 59 47	12 5 30	12 4 45	11 55 56	11 46 19	11 44 22	11 54 17
14	12 9 15	12 14 23	12 9 23	12 0 20	11 56 12	12 0 0	12 5 37	12 4 34	11 55 35	11 46 5	11 44 31	11 54 45
15	12 9 37	12 14 20	12 9 6	12 0 5	11 56 12	12 0 12	12 5 44	12 4 22	11 55 13	11 45 51	11 44 41	11 55 14
16	12 9 57	12 14 16	12 8 49	11 59 50	11 56 12	12 0 25	12 5 50	12 4 10	11 54 52	11 45 38	11 44 52	11 55 43
17	12 10 17	12 14 12	12 8 32	11 59 36	11 56 13	12 0 38	12 5 55	12 3 58	11 54 31	11 45 26	11 45 3	11 56 12
18	12 10 36	12 14 7	12 8 14	11 59 22	11 56 15	12 0 50	12 6 0	12 3 45	11 54 9	11 45 14	11 45 15	11 56 41
19	12 10 55	12 14 2	12 7 56	11 59 8	11 56 18	12 1 3	12 6 4	12 3 31	11 53 48	11 45 3	11 45 28	11 57 11
20	12 11 13	12 13 56	12 7 38	11 58 55	11 56 21	12 1 16	12 6 8	12 3 17	11 53 27	11 44 52	11 45 42	11 57 41
21	12 11 30	12 13 49	12 7 20	11 58 42	11 56 24	12 1 29	12 6 11	12 3 3	11 53 6	11 44 42	11 45 57	11 58 11
22	12 11 46	12 13 41	12 7 2	11 58 30	11 56 28	12 1 42	12 6 14	12 2 48	11 52 45	11 44 33	11 46 13	11 58 41
23	12 12 2	12 13 33	12 6 44	11 58 18	11 56 32	12 1 55	12 6 16	12 2 33	11 52 24	11 44 24	11 46 29	11 59 11
24	12 12 17	12 13 24	12 6 25	11 58 7	11 56 37	12 2 8	12 6 18	12 2 17	11 52 3	11 44 16	11 46 46	11 59 41
25	12 12 31	12 13 15	12 6 6	11 57 56	11 56 43	12 2 21	12 6 19	12 2 1	11 51 42	11 44 9	11 47 4	12 0 11
26	12 12 44	12 13 5	12 5 48	11 57 45	11 56 49	12 2 33	12 6 19	12 1 45	11 51 22	11 44 3	11 47 23	12 0 41
27	12 12 57	12 12 54	12 5 30	11 57 35	11 56 55	12 2 45	12 6 19	12 1 28	11 51 2	11 43 57	11 47 42	12 1 11
28	12 13 8	12 12 43	12 5 12	11 57 26	11 57 2	12 2 58	12 6 18	12 1 11	11 50 42	11 43 52	11 48 2	12 1 40
29	12 13 19	.....	12 4 53	11 57 17	11 57 10	12 3 11	12 6 17	12 0 53	11 50 22	11 43 48	11 48 23	12 2 10
30	12 13 29	.....	12 4 34	11 57 9	11 57 18	12 3 23	12 6 15	12 0 35	11 50 2	11 43 45	11 48 45	12 2 39
31	12 13 38	.....	12 4 16	.....	11 57 26	.....	12 6 12	12 0 17	.....	11 43 42	.....	12 3 8

(Insert these tables in the "Instructions for Making Forest Surveys and Maps," 1912, page 22.)

TABLE 2b.—*Showing the hour, minute, and second at which the sun will bear exactly south. The watch must be set to local mean time (not standard, nor sidereal, nor sun time).*

FOR THE YEAR 1914 IN THE WESTERN UNITED STATES.

Day of month.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	H. m. s.	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*	*H. m. s.*
1.....	12 3 37	12 13 45	12 12 35	12 4 3	11 57 4	11 57 34	12 3 32	12 6 11	12 0 3	11 49 48	11 43 41	11 49 1
2.....	12 4 5	12 13 53	12 12 23	12 3 45	11 56 56	11 57 43	12 3 44	12 6 7	11 59 44	11 49 29	11 43 39	11 49 24
3.....	12 4 33	12 14 0	12 12 10	12 3 27	11 56 49	11 57 52	12 3 55	12 6 3	11 59 25	11 49 10	11 43 39	11 49 47
4.....	12 5 1	12 14 6	12 11 57	12 3 9	11 56 43	11 58 2	12 4 6	12 5 58	11 59 5	11 48 51	11 43 39	11 50 11
5.....	12 5 28	12 14 11	12 11 44	12 2 51	11 56 38	11 58 12	12 4 17	12 5 52	11 58 45	11 48 33	11 43 40	11 50 35
6.....	12 5 54	12 14 15	12 11 30	12 2 34	11 56 33	11 58 22	12 4 27	12 5 46	11 58 25	11 48 15	11 43 42	11 51 0
7.....	12 6 20	12 14 19	12 11 16	12 2 17	11 56 28	11 58 33	12 4 37	12 5 39	11 58 5	11 47 57	11 43 45	11 51 25
8.....	12 6 46	12 14 22	12 11 1	12 2 0	11 56 24	11 58 44	12 4 46	12 5 32	11 57 45	11 47 40	11 43 49	11 51 51
9.....	12 7 11	12 14 24	12 10 46	12 1 43	11 56 20	11 58 55	12 4 55	12 5 24	11 57 24	11 47 24	11 43 53	11 52 18
10.....	12 7 36	12 14 25	12 10 31	12 1 26	11 56 17	11 59 7	12 5 4	12 5 15	11 57 3	11 47 8	11 43 58	11 52 45
11.....	12 8 0	12 14 25	12 10 15	12 1 10	11 56 15	11 59 19	12 5 13	12 5 6	11 56 42	11 46 52	11 44 4	11 53 12
12.....	12 8 24	12 14 25	12 9 59	12 0 54	11 56 13	11 59 31	12 5 21	12 4 57	11 56 21	11 46 37	11 44 11	11 53 40
13.....	12 8 47	12 14 24	12 9 43	12 0 38	11 56 11	11 59 43	12 5 28	12 4 47	11 56 0	11 46 22	11 44 19	11 54 8
14.....	12 9 9	12 14 22	12 9 26	12 0 22	11 56 11	11 59 56	12 5 35	12 4 36	11 55 39	11 46 8	11 44 28	11 54 37
15.....	12 9 30	12 14 19	12 9 9	12 0 7	11 56 11	12 0 8	12 5 42	12 4 25	11 55 18	11 45 54	11 44 38	11 55 6
16.....	12 9 51	12 14 16	12 8 52	11 59 52	11 56 11	12 0 21	12 5 48	12 4 13	11 54 57	11 45 41	11 44 48	11 55 35
17.....	12 10 11	12 14 12	12 8 35	11 59 38	11 56 12	12 0 34	12 5 53	12 4 1	11 54 36	11 45 29	11 44 59	11 56 4
18.....	12 10 31	12 14 7	12 8 17	11 59 24	11 56 14	12 0 47	12 5 58	12 3 48	11 54 25	11 45 17	11 45 11	11 56 34
19.....	12 10 50	12 14 2	12 7 59	11 59 11	11 56 16	12 1 0	12 6 3	12 3 35	11 53 54	11 45 6	11 45 24	11 57 4
20.....	12 11 8	12 13 56	12 7 41	11 58 58	11 56 19	12 1 13	12 6 7	12 3 21	11 53 33	11 44 55	11 45 38	11 57 34
21.....	12 11 25	12 13 50	12 7 23	11 58 45	11 56 23	12 1 26	12 6 11	12 3 7	11 53 12	11 44 45	11 45 53	11 58 4
22.....	12 11 42	12 13 42	12 7 55	11 58 33	11 56 27	12 1 39	12 6 14	12 2 52	11 52 51	11 44 36	11 46 9	11 58 34
23.....	12 11 58	12 13 34	12 6 47	11 58 21	11 56 31	12 1 52	12 6 16	12 2 37	11 52 30	11 44 27	11 46 25	11 59 4
24.....	12 12 13	12 13 26	12 6 29	11 58 9	11 56 36	12 2 5	12 6 18	12 2 22	11 52 9	11 44 19	11 46 42	11 59 34
25.....	12 12 27	12 13 17	12 6 11	11 57 58	11 56 42	12 2 18	12 6 19	12 2 6	11 51 48	11 44 12	11 47 0	12 0 4
26.....	12 12 41	12 13 7	12 5 52	11 57 48	11 56 48	12 2 31	12 6 20	12 1 49	11 51 27	11 44 5	11 47 18	12 0 33
27.....	12 12 54	12 12 57	12 5 34	11 57 38	11 56 54	12 2 44	12 6 20	12 1 32	11 51 7	11 43 59	11 47 37	12 1 3
28.....	12 13 6	12 12 46	12 5 16	11 57 29	11 57 1	12 2 57	12 6 19	12 1 15	11 50 47	11 43 54	11 47 57	12 1 33
29.....	12 13 17	.....	12 4 57	11 57 20	11 57 9	12 3 9	12 6 18	12 0 58	11 50 27	11 43 50	11 48 18	12 2 2
30.....	12 13 27	.....	12 4 39	11 57 12	11 57 17	12 3 21	12 6 16	12 0 40	11 50 7	11 43 46	11 48 39	12 2 31
31.....	12 13 36	.....	12 4 21	.....	11 57 25	.....	12 6 14	12 0 22	.....	11 43 43	.....	12 3 0

PLANE TABLE.

For making any map the plane table is the best instrument in use. Instead of taking notes, as in running compass lines, the surveyor plats his work in the field and can thus always see the progress made. Errors and omissions are discovered quickly and rectified.

The paper upon which the map is to be made is fastened to the plane-table board by thumb tacks, and upon it rests the alidade, a straightedge or ruler with folding sights like a compass. From a point on the paper which represents the starting point on the ground over which the table is standing the surveyor draws lines on the paper with the alidade to the various topographic features which are to be mapped. From start to finish of the survey it must at all stations retain the same orientation—that is to say, at every station where the table is set up its sides must be exactly parallel to its position at the original station.

There are several methods, all based upon the same principles. If an isolated block of forest is to be bounded by a survey, the method would be:

Set up at *A* with one side of the table bearing approximately north and south. As *A* is near the southeast corner of the tract, begin to draw at the corresponding place on the paper. With the alidade draw a line from *A* toward *B*. Measure the distance *AB* on the ground and scale the proportionate distance on the paper. Set the table at *B*. With the alidade on the drawn line take a backsight on *A*. The table will then be oriented or parallel to its position when at *A*. Draw a line on the paper from *B* toward *C*. Measure it and

scale on the map. Proceed as before, and the result will be a map which will truly represent the lines on the ground. (See fig. 5.)

In this case the points *C* and *D* were not visible from *A*, but if, instead of being a block of forest, the area were an open meadow, then a second method would be used.

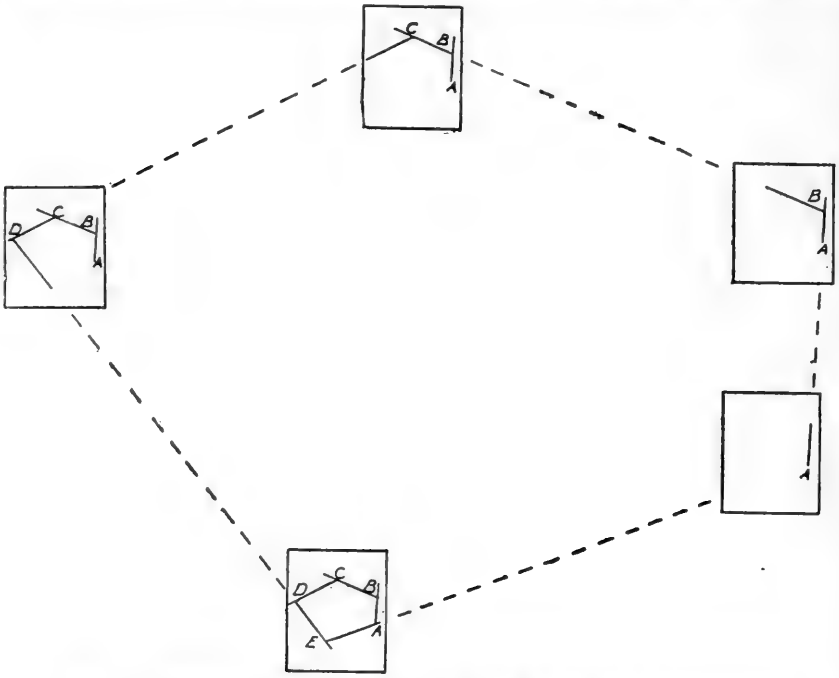


FIG. 5.—Plane-table method in which the table is set up at all the stations.

Set up at *A*. Draw lines to *B*, *C*, *D*, and *E*. Measure *AB*. Set up at *B*. Orient on *A*. Draw lines to *C*, *D*, and *E*. The intersections of the line will give the other three points. The line *AB* is a base line. (See fig. 6.)

The third method is an extension of the second and involves some near-by points which can not be located

from the base line. From *A* and *B* the points *C*, *D*, *E*, and *F* are intersected, and one sight is taken on *G*, which is obviously too nearly in line with the base line to be accurately intersected. Subsequently the table is set up at *C* and oriented by taking sights on *A*, *B*, *D*, *E*, and *F*. It is then easy to intersect *G*, and also get

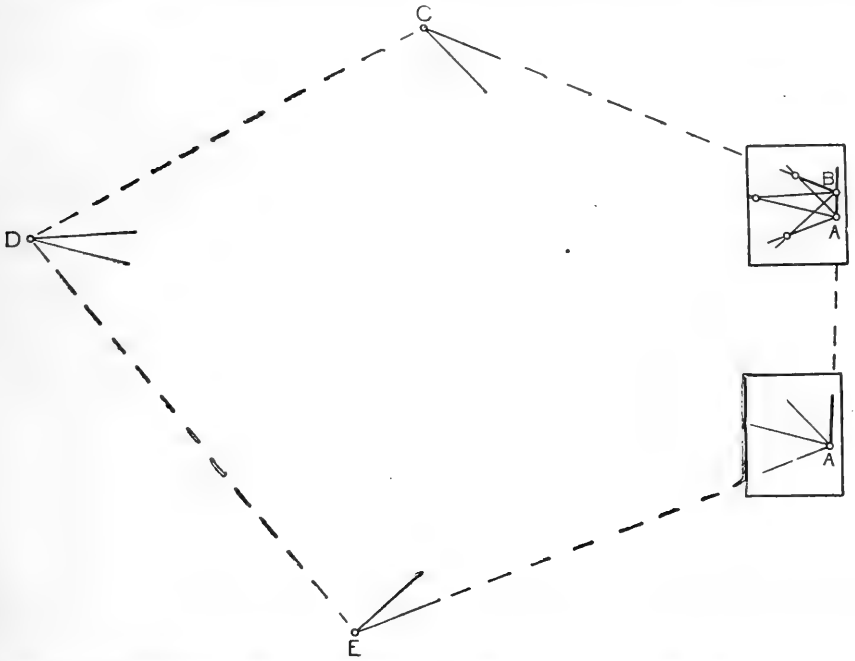


FIG. 6.—Plane-table method in which the table is set up at two stations and the remaining three are located by intersections.

a sight on *H*, which was not visible before. *H* may be intersected from *G*. (See fig. 7.)

A fourth method is employed when the table must be set up at an unknown point from which three or more known points are visible. This is the "three-point problem," in which the suveyor "picks up" his

location. Suppose that *C*, *D*, and *E* were located by the third method and are high and well-defined peaks. They form a triangle which can be accurately platted on the paper, and the best plan is to prick in the points with a fine needle. The surveyor will then proceed

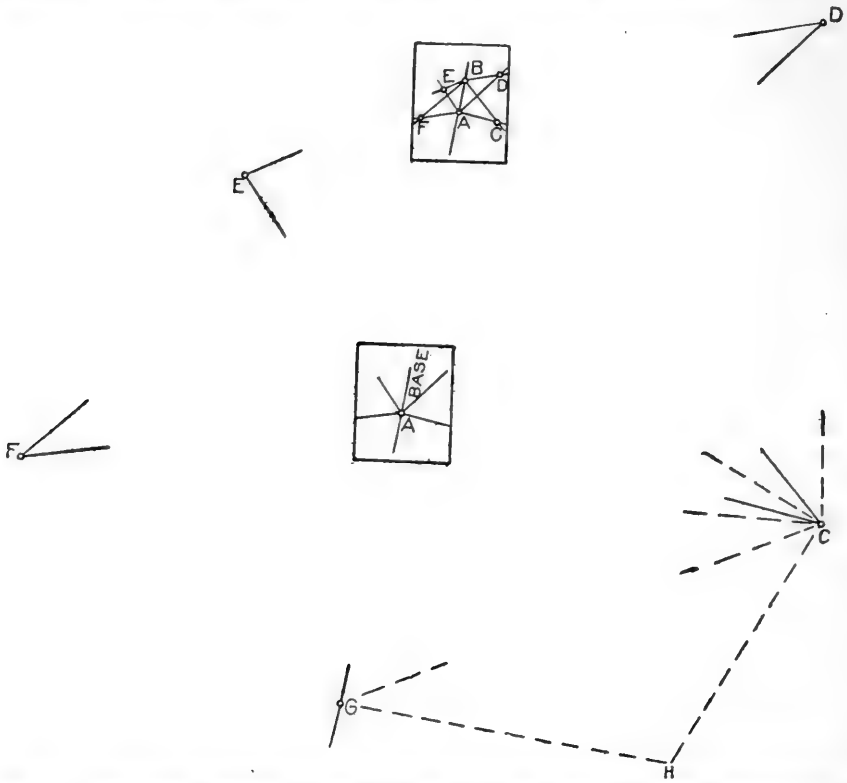


FIG. 7.—Plane-table method of locating points on both sides of a base line which are to be occupied later and the survey extended.

by setting up the table at the point which is to be located and from which he can see the three peaks. Orient approximately by compass. With the alidade draw lines from each peak toward the point of set-up. If the three lines intersect, the desired point is located,

except as noted below. If the lines do not intersect, the orientation may be changed until they do, but an easier plan is to fasten a piece of tracing cloth on the table and assume a point from which the lines may be drawn toward the peaks. The tracing may then be shifted over the paper to find a position at which the lines will

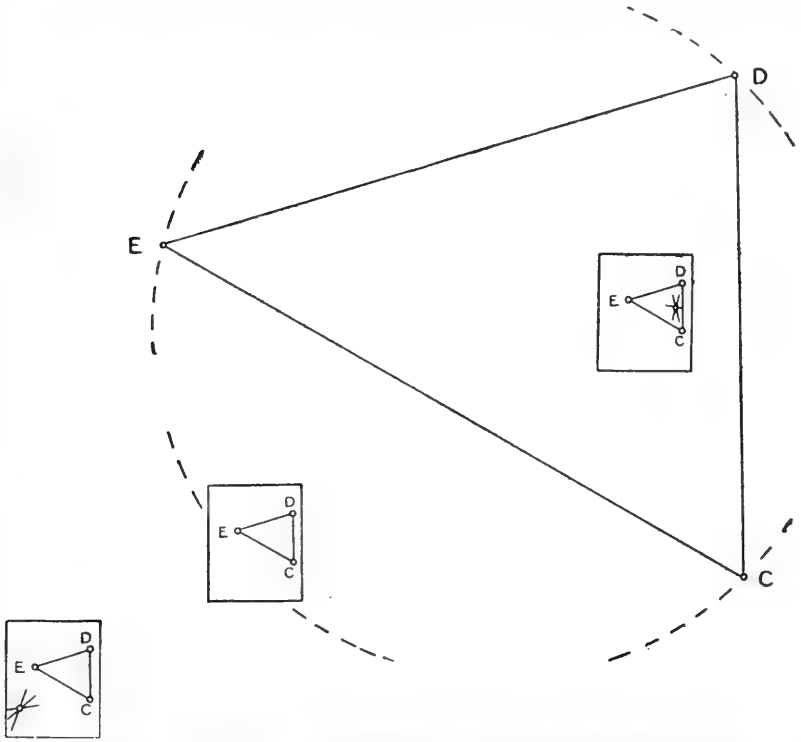


FIG. 8.—Plane-table method of finding location from three points.

exactly cover the three needle holes on the paper. This method is reliable when the desired location is within the triangle, but it is useless when the table is set up on or near a circle which would pass through the three peaks. For this reason four or more points should be used if possible. (See fig. 8.)

With the thumb pressing the release, the sight is taken on the object and the height is read at the same time; or the thumb may be lifted, and the pendulum thus being clamped, the height of the tree may be read through the window.

If the observer stands only 50 feet from the tree the reading must be divided by 2. If he stands 200 feet away it must be multiplied by 2, and proportionately for other distances.

The reading gives the height above the level of the eye. Allowance must be made if the observer's eye is above or below the stump height of the tree.

The notebook and pencil are held in the right hand while an observation is being taken, and the notebook is passed to the left hand when the observation is entered. The hypsometer being on the back of the fingers allows free play for the thumb, palm, and ends of the fingers of the left hand to hold the notebook. In moving from station to station the right hand is then free to assist in getting through the brush or in crossing logs.

The circular pendulum is graduated to tangents. Therefore it may be used to determine the per cent of grade of a road or trail. For this purpose sights may be taken downhill as well as uphill. No conversion of figures is necessary. If the reading is 10 the grade is 10 per cent. It will not hereafter be necessary to use pocket levels for this class of work, since the hypsometer-grademeter answers every purpose.

DETAILS OF SURVEYING.

MEASUREMENTS.

The most frequent source of error in pacing, chaining, or steel taping is in counting the tallies—assuming that the mechanical part of the work is well done. The memory should not be trusted. The only safe plan is to enter each tally in the field notes as soon as that tally is completed and the pins or stakes have been counted by both chainmen and before the next tally is begun. When timber is being estimated along the survey line this error is not likely to occur, as the numbers on the timber sheets are a check upon the work.

If a pair of amateur chainmen went over some open level country and reported a distance of 174.62 chains, an error, if one existed, would probably be found in the "tens" or tallies, and a resurvey would give 164.62 or 184.62 chains. The standard chain has a length of 66 feet. If any other unit of linear measure is used, it must be made clear in the notes.

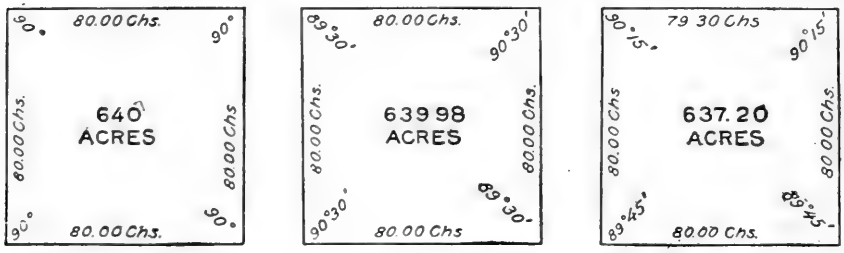
For some classes of work steel tapes or "band chains" are preferable, because, being lighter, they can be longer and stretched straighter than chains.

CONCERNING ACCURACY.

The field work of the Forest Service extends over millions of acres of wild, very rough, and frequently almost inaccessible lands. In the surveying and mapping of such lands, it should be understood that the term "accuracy" does not call for the degree of precision which would be applied to city lots having a value of

$1,000 per square foot. The surveys of the Forest Service call for *practical accuracy*, rather than technical correctness or precision.

Figure 10 shows the changing areas in the survey of a square mile in which there is a compass error of one-fourth degree. When measurements close, but not at right angles, the result is a diamond, and the loss in area is about 0.02 of an acre, representing a value of only 5 or 10 cents. In a converging section the loss may be 2.80



Perfect square. Diamond. Converging quadrangle.

FIG. 10.—Areas of a section containing a compass error of 0.25 degree.

acres, but in either instance such a survey is considered to inclose a conventional section of 640 acres, and this will also be the case if there is an excess acreage to the same extent. To survey a perfect square would be very expensive and not justifiable in view of the trifling values involved.

TRAVERSE.

When a survey is run along a road or stream, or follows the crest of a divide, the line "meanders" and consists of a number of short courses and distances. The courses are read from the north end of the needle and platted on the map with a protractor. Whenever

the actual change in latitude or departure (longitude) is desired, it may be computed with the traverse table.

In platting with the protractor care should be used that all the angles are set off from the same meridian, otherwise the errors will accumulate. The angles of all courses in surveying are measured from the north and south cardinals toward the east or west, and they should be platted the same. The figures on some protractors are misleading in this respect.

23682°—12——3

TABLE 3.—*Traverse.*

Course.	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
° ′											° ′
0 15	1.0000	0.0044	2.0000	0.0087	3.0000	0.0131	4.0000	0.0175	5.0000	0.0218	89 45
30	0000	0087	1.9999	0175	2.9999	0262	3.9998	0349	4.9998	0436	30
45	0.9999	0131	9998	0262	9997	0393	9997	0524	9996	0654	15
1 0	9998	0175	9997	0349	9995	0524	9994	0698	9992	0873	89 0
15	9998	0218	9995	0436	9993	0654	9990	0873	9988	1091	45
30	9997	0262	9993	0524	9990	0785	9986	1047	9983	1309	30
45	9995	0305	9991	0611	9986	0916	9981	1222	9977	1527	15
2 0	9994	0349	9988	0698	9982	1047	9976	1396	9970	1745	88 0
15	9992	0393	9985	0785	9977	1178	9969	1570	9961	1963	45
30	9990	0436	9981	0872	9971	1309	9962	1745	9952	2181	30
45	0.9988	0.0480	1.9977	0.0960	2.9965	0.1439	3.9954	0.1919	4.9942	0.2399	15
3 0	9986	0523	9973	1047	9959	1570	9945	2093	9931	2617	87 0
15	9984	0567	9968	1134	9952	1701	9936	2268	9920	2835	45
30	9981	0610	9963	1221	9944	1831	9925	2412	9907	3052	30
45	9979	0654	9957	1308	9936	1962	9914	2616	9893	3270	15
4 0	9976	0698	9951	1395	9927	2093	9903	2790	9878	3488	86 0
15	9973	0741	9945	1482	9918	2223	9890	2964	9863	3705	45
30	9969	0785	9938	1569	9908	2354	9877	3138	9846	3923	30
45	9966	0828	9931	1656	9897	2484	9863	3312	9828	4140	15
5 0	9962	6872	9924	1743	9886	2615	9848	3486	9819	4358	85 0
15	0.9958	0.0915	1.9916	0.1830	2.9874	0.2745	3.9832	0.3660	4.9790	0.4575	45
30	9954	0958	9908	1917	9862	2875	9816	3834	9770	4792	30
45	9950	1002	9899	2004	9849	3006	9799	4008	9748	5009	15
6 0	9945	1045	9890	2091	9836	3136	9781	4181	9726	5226	84 0
15	9941	1089	9881	2177	9822	3266	9762	4355	9703	5443	45
30	9936	1132	9871	2264	9807	3396	9743	4528	9679	5660	30
45	9931	1175	9861	2351	9792	3526	9723	4701	9653	5877	15
7 0	9925	1219	9851	2437	9776	3656	9702	4875	9627	6093	83 0
15	9920	1262	9840	2524	9760	3786	9680	5048	9600	6310	45
30	9914	1305	9829	2611	9743	3916	9658	5221	9572	6526	30
45	0.9909	0.1349	1.9817	0.2697	2.9726	0.4046	3.9635	0.5394	4.9543	0.6743	15
8 0	9903	1392	9805	2783	9708	4175	9611	5567	9513	6959	82 0
15	9897	1435	9793	2870	9690	4305	9586	5740	9483	7175	45
30	9890	1478	9780	2956	9670	4434	9561	5912	9451	7390	30
45	9884	1521	9767	3042	9651	4564	9534	6085	9418	7606	15
9 0	9877	1564	9754	3129	9631	4693	9508	6257	9384	7822	81 0
15	9870	1607	9740	3215	9610	4822	9480	6430	9350	8037	45
30	9863	1650	9726	3301	9589	4951	9451	6602	9314	8252	30
45	9856	1693	9711	3387	9567	5080	9422	6774	9278	8467	15
10 0	9848	1736	9696	3473	9544	5209	9392	6946	9240	8682	80 0
15	0.9840	0.1779	1.9681	0.3559	2.9521	0.5338	3.9362	0.7118	4.9202	0.8897	45
30	9833	1822	9665	3645	9498	5467	9330	7289	9163	9112	30
45	9825	1865	9649	3730	9474	5596	9298	7461	9123	9326	15
11 0	9816	1908	9633	3816	9449	5724	9265	7632	9081	9540	79 0
15	9808	1951	9616	3902	9424	5853	9231	7804	9039	9755	45
30	9799	1994	9598	3987	9398	5981	9197	7975	8996	9968	30
45	9790	2036	9581	4073	9371	6109	9162	8146	8952	1.0182	15
12 0	9781	2079	9563	4158	9344	6237	9126	8316	8907	0396	78 0
15	9772	2122	9545	4244	9317	6365	9089	8487	8862	0609	45
30	9763	2164	9526	4329	9289	6493	9052	8658	8815	0822	30
45	0.9753	0.2207	1.9507	0.4414	2.9260	0.6621	3.9014	0.8828	4.8767	1.1035	15
13 0	9744	2250	9487	4499	9231	6749	8975	8998	8719	1248	77 0
15	9734	2292	9468	4584	9201	6876	8935	9168	8669	1460	45
30	9724	2334	9447	4669	9171	7003	8895	9338	8618	1672	30
45	9713	2377	9427	4754	9140	7131	8854	9507	8567	1884	15
14 0	9703	2419	9406	4838	9109	7258	8812	9677	8515	2096	76 0
15	9692	2462	9385	4923	9077	7385	8769	9846	8462	2308	45
30	9681	2504	9363	5008	9044	7511	8726	1.0015	8407	2519	30
45	9670	2546	9341	5092	9011	7638	8682	0184	8352	2730	15
15 0	9659	2588	9319	5176	8978	7765	8637	0353	8296	2941	75 0
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Course.
	Dist. 1.		Dist. 2.		Dist. 3		Dist. 4.		Dist. 5.		

TABLE 3.—*Traverse*—Continued.

Course.		Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		
		Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
°	′											° ′
15	15	0.9648	0.2630	1.9296	0.5261	2.8944	0.7891	3.8591	1.0521	4.8239	1.3151	74 45
	30	9636	2672	9273	5345	8909	8017	8545	0690	8182	3302	30
	45	9625	2714	9249	5429	8874	8143	8498	0858	8123	3572	15
16	0	9613	2756	9225	5513	8838	8269	8450	1025	8063	3782	74 0
	15	9600	2798	9201	5597	8801	8395	8402	1195	8002	3991	45
	30	9588	2840	9176	5680	8765	8520	8353	1361	7941	4201	30
	45	9576	2882	9151	5764	8727	8646	8303	1528	7879	4410	15
17	0	9563	2924	9126	5847	8689	8771	8252	1695	7815	4619	73 0
	15	9550	2965	9100	5931	8651	8896	8201	1862	7751	4827	45
	30	9537	3007	9074	6014	8612	9021	8149	2028	7686	5035	30
	45	0.9524	0.3049	1.9048	0.6097	2.8572	0.9146	3.8096	1.2195	4.7620	1.5243	15
18	0	9511	3090	9021	6180	8532	9271	8042	2361	7553	5451	72 0
	15	9497	3132	8994	6263	8491	9395	7988	2527	7485	5658	45
	30	9483	3173	8966	6346	8450	9519	7933	2692	7416	5865	30
	45	9469	3214	8939	6429	8408	9643	7877	2858	7347	6072	15
19	0	9455	3256	8910	6511	8366	9767	7821	3023	7276	6278	71 0
	15	9441	3297	8882	6594	8323	9891	7764	3188	7204	6485	45
	30	9426	3338	8853	6676	8279	1.0014	7706	3352	7132	6690	30
	45	9412	3379	8824	6758	8235	0138	7647	3517	7059	6896	15
20	0	9397	3420	8794	6840	8191	0261	7588	3681	6985	7101	70 0
	15	0.9382	0.3461	1.8764	0.6922	2.8146	1.0384	3.7528	1.3845	4.6910	1.7306	45
	30	9367	3502	8733	7004	8100	0506	7467	4008	6834	7510	30
	45	9351	3543	8703	7086	8054	0629	7405	4172	6757	7715	15
21	0	9336	3584	8672	7167	8007	0751	7343	4335	6679	7918	69 0
	15	9320	3624	8640	7249	7960	0873	7280	4498	6600	8122	45
	30	9304	3665	8608	7330	7913	0995	7217	4660	6521	8325	30
	45	9288	3706	8576	7411	7864	1177	7152	4822	6440	8528	15
22	0	9272	3746	8544	7492	7816	1238	7087	4984	6359	8730	68 0
	15	9255	3786	8511	7573	7766	1359	7022	5146	6277	8932	45
	30	9239	3827	8478	7654	7716	1481	6955	5307	6194	9134	30
	45	0.9222	0.3867	1.8444	0.7734	2.7666	1.1601	3.6888	1.5468	4.6110	1.9336	15
23	0	9205	3907	8410	7815	7615	1722	6820	5629	6025	9537	67 0
	15	9188	3947	8376	7895	7564	1842	6752	5790	5940	9737	45
	30	9171	3987	8341	7975	7512	1962	6682	5950	5853	9937	30
	45	9153	4027	8306	8055	7459	2082	6612	6110	5766	2.0137	15
24	0	9135	4067	8271	8135	7406	2202	6542	6269	5677	0337	66 0
	15	9118	4107	8235	8214	7353	2322	6470	6429	5588	0536	45
	30	9100	4147	8199	8294	7299	2441	6398	6588	5498	0735	30
	45	9081	4187	8163	8373	7214	2560	6326	6746	5407	0933	15
25	0	9063	4226	8126	8452	7189	2679	6252	6905	5315	1131	65 0
	15	0.9045	0.4266	1.8099	0.8531	2.7034	1.2797	3.6178	1.7063	4.5223	2.1328	45
	30	9026	4305	8052	8610	7078	2915	6103	7220	5129	1526	30
	45	9007	4344	8014	8689	7021	3033	6028	7378	5035	1722	15
26	0	8988	4384	7976	8767	6964	3151	5952	7535	4940	1919	64 0
	15	8969	4423	7937	8846	6906	3269	5875	7692	4844	2114	45
	30	8949	4462	7899	8924	6848	3386	5797	7848	4747	2310	30
	45	8930	4501	7860	9002	8789	3503	5719	8004	4649	2505	15
27	0	8910	4540	7820	9080	6730	3620	5640	8160	4550	2700	63 0
	15	8890	4579	7780	9157	6671	3736	5561	8315	4451	2894	45
	30	8870	4617	7740	9235	6610	3852	5480	8470	4351	3087	30
	45	0.8850	0.4656	1.7700	0.9312	2.6550	1.3968	3.5400	1.8625	4.4249	2.3281	15
28	0	8829	4695	7659	9389	6488	4084	5318	8779	4147	3474	62 0
	15	8809	4733	7618	9466	6427	4200	5236	8933	4045	3666	45
	30	8788	4772	7576	9543	6365	4315	5153	9086	3941	3858	30
	45	8767	4810	7535	9620	6302	4430	5069	9240	3836	4049	15
29	0	8746	4848	7492	9696	6239	4544	4985	9392	3731	4240	61 0
	15	8725	4886	7450	9772	6175	4659	4900	9545	3625	4431	45
	30	8704	4924	7407	9848	6111	4773	4814	9697	3518	4621	30
	45	8682	4962	7364	9924	6046	4886	4728	9849	3410	4811	15
30	0	8660	5000	7321	1.0000	5981	5000	4641	2.0000	3301	5000	60 0
		Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Course.
		Dist. 1.		Dist. 2		Dist. 3.		Dist. 4.		Dist. 5.		

TABLE 3.—*Traverse*—Continued.

Course.	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
° ′											° ′
30 15	0.8638	0.5038	1.7277	1.0075	2.5915	1.5113	3.4553	2.0151	4.3192	2.5189	59 45
30	8616	5075	7233	0151	5849	5226	4465	0302	3081	5377	30
45	8594	5113	7188	0226	5782	5339	4376	0452	2970	5565	15
31 0	8572	5150	7142	0301	5715	5451	4287	0602	2858	5752	59 0
15	8549	5188	7098	0375	5647	5563	4196	0751	2746	5939	45
30	8526	5225	7053	0450	5579	5675	4106	0900	2632	6125	30
45	8504	5262	7007	0524	5511	5786	4014	1049	2518	6311	15
32 0	8480	5299	6961	0598	5441	5898	3922	1197	2402	6496	58 0
15	8457	5336	6915	0672	5372	6008	3829	1345	2286	6681	45
30	8434	5373	6868	0746	5302	6119	3736	1492	2170	6865	30
45	0.8410	0.5410	1.6821	1.0819	2.5231	1.6229	3.3642	2.1639	4.2052	2.7049	15
33 0	8387	5446	6773	0893	5160	6339	3547	1786	1934	7232	57 0
15	8363	5483	6726	0966	5089	6449	3451	1932	1814	7415	45
30	8339	5519	6678	1039	5017	6558	3355	2077	1694	7597	30
45	8315	5556	6629	1111	4944	6667	3259	2223	1573	7779	15
34 0	8290	5592	6581	1184	4871	6776	3162	2368	1452	7960	56 0
15	8266	5628	6532	1256	4798	6884	3064	2512	1329	8140	45
30	8241	5664	6483	1328	4724	6992	2965	2656	1206	8320	30
45	8216	5700	6433	1400	4649	7100	2866	2800	1082	8500	15
35 0	8192	5736	6383	1472	4575	7207	2766	2943	0958	8679	55 0
15	0.8166	0.5771	1.6333	1.1543	2.4499	1.7314	3.2666	2.3086	4.0832	2.8857	45
30	8141	5807	6282	1614	4423	7421	2565	3228	0706	9035	30
45	8116	5842	6231	1685	4347	7527	2463	3370	0579	9212	15
36 0	8090	5878	6180	1756	4271	7634	2361	3511	0451	9389	54 0
15	8064	5913	6129	1826	4193	7739	2258	3652	0322	9565	45
30	8039	5948	6077	1896	4116	7845	2154	3793	0193	9741	30
45	8013	5983	6025	1966	4038	7950	2050	3933	0063	9916	15
37 0	7986	6018	5973	2036	3959	8054	1945	4073	3.9932	3.0091	53 0
15	7960	6053	5920	2106	3880	8159	1840	4212	9800	0365	45
30	7934	6088	5867	2175	3801	8263	1734	4350	9668	0438	30
45	0.7907	0.6122	1.5814	1.2244	2.3721	1.8367	3.1628	2.4489	3.9534	3.0611	15
38 0	7880	6157	5760	2313	3640	8470	1520	4626	9400	0783	52 0
15	7853	6191	5706	2382	3560	8573	1413	4764	9266	0955	45
30	7826	6225	5652	2450	3478	8675	1304	4901	9130	1126	30
45	7799	6259	5598	2518	3397	8778	1195	5037	8994	1296	15
39 0	7771	6293	5543	2586	3314	8880	1086	5173	8857	1466	51 0
15	7744	6327	5488	2654	3232	8981	0976	5308	8720	1635	45
30	7716	6361	5432	2722	3149	9082	0865	5443	8581	1804	30
45	7688	6394	5377	2789	3065	9183	0754	5578	8442	1972	15
40 0	7660	6428	5321	2856	2981	9284	0642	5712	8302	2139	50 0
15	0.7632	0.6461	1.5265	1.2922	2.2897	1.9384	3.0529	2.5845	3.8162	3.2306	45
30	7604	6494	5208	2989	2812	9483	0416	5978	8020	2472	30
45	7576	6528	5151	3055	2727	9583	0303	6110	7878	2638	15
41 0	7547	6561	5094	3121	2641	9682	0188	6242	7735	2803	49 0
15	7518	6593	5037	3187	2555	9780	0074	6374	7592	2967	45
30	7490	6626	4979	3252	2469	9879	2.9958	6505	7448	3131	30
45	7461	6659	4921	3318	2382	9976	9842	6635	7303	3294	15
42 0	7431	6691	4863	3383	2294	2.0074	9726	6765	7157	3457	48 0
15	7402	6724	4804	3447	2207	0171	9609	6895	7011	3618	45
30	7373	6756	4746	3512	2118	0268	9491	7024	6864	3780	30
45	0.7343	0.6788	1.4686	1.3576	2.2030	2.0364	2.9373	2.7152	3.6716	3.3940	15
43 0	7314	6820	4627	3640	1941	0460	9254	7280	6568	4100	47 0
15	7284	6852	4567	3704	1851	0555	9135	7407	6419	4259	45
30	7254	6884	4507	3767	1761	0651	9015	7534	6269	4418	30
45	7224	6915	4447	3830	1671	0745	8895	7661	6118	4576	15
44 0	7193	6947	4387	3893	1580	0840	8774	7786	5967	4733	46 0
15	7163	6978	4326	3956	1489	0934	8652	7912	5815	4890	45
30	7133	7009	4265	4018	1398	1027	8530	8036	5663	5045	30
45	7102	7040	4204	4080	1306	1120	8407	8161	5509	5201	15
45 0	7071	7071	4142	4142	1213	1213	8284	8284	5355	5355	45 0
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Course.
	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		

TABLE 3.—*Traverse*—Continued.

Course.	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
° ′											° ′
0 15	5.9999	0.0262	6.9999	0.0305	7.9999	0.0349	8.9999	0.0393	9.9999	0.0436	89 45
30	9998	0524	9997	0611	9997	0698	9997	0785	9996	0873	30
45	9995	0785	9994	0916	9993	1047	9992	1178	9996	1309	15
1 0	9991	1047	9989	1222	9988	1396	9986	1571	9985	1745	89 0
15	9986	1309	9983	1527	9981	1745	9979	1963	9976	2181	45
30	9979	1571	9976	1832	9973	2094	9969	2356	9966	2618	30
45	9972	1832	9967	2138	9963	2443	9958	2748	9953	3054	15
2 0	9963	2094	9957	2443	9951	2792	9945	3141	9939	3490	88 0
15	9954	2356	9946	2748	9938	3141	9931	3533	9923	3926	45
30	9943	2617	9933	3053	9924	3490	9914	3926	9905	4362	30
45	5.9931	0.2879	6.9919	0.3358	7.9908	0.3838	8.9896	0.4318	9.9885	0.4798	15
3 0	9918	3140	9904	3664	9890	4187	9877	4710	9863	5234	87 0
15	9904	3402	9887	3968	9871	4535	9855	5102	9839	5669	45
30	9888	3663	9869	4273	9851	4884	9832	5494	9813	6105	30
45	9872	3924	9850	4578	9829	5232	9807	5886	9786	6540	15
4 0	9854	4185	9829	4883	9805	5581	9781	6278	9756	6976	86 0
15	9835	4447	9808	5188	9780	5929	9753	6670	9725	7411	45
30	9815	4708	9784	5492	9753	6277	9723	7061	9692	7846	30
45	9794	4968	9760	5797	9725	6625	9691	7453	9657	8281	15
5 0	9772	5229	9734	6101	9696	6972	9658	7844	9619	8716	85 0
15	5.9748	0.5490	6.9706	0.6405	7.9664	0.7320	8.9622	0.8235	9.9580	0.9150	45
30	9724	5751	9678	6709	9632	7668	9586	8626	9540	9585	30
45	9698	6011	9648	7013	9597	8015	9547	9017	9497	1.0019	15
6 0	9671	6272	9617	7317	9562	8362	9507	9408	9452	0453	84 0
15	9643	6532	9584	7621	9525	8709	9465	9798	9406	0887	45
30	9614	6792	9550	7924	9486	9056	9421	1.0188	9357	1320	30
45	9584	7052	9515	8228	9445	9403	9376	0578	9307	1754	15
7 0	9553	7312	9478	8531	9404	9750	9329	0968	9255	2187	83 0
15	9520	7572	9440	8834	9360	1.0096	9280	1358	9200	2620	45
30	9487	7832	9401	9137	9316	0442	9230	1747	9144	3053	30
45	5.9452	0.8091	6.9361	0.9440	7.9269	1.0788	8.9178	1.2137	9.9087	1.3485	15
8 0	9416	8350	9319	9742	9221	1134	9124	2526	9027	3917	82 0
15	9379	8610	9276	1.0044	9172	1479	9069	2914	8965	4349	45
30	9341	8869	9231	0347	9121	1825	9011	3303	8902	4781	30
45	9302	9127	9185	0649	9069	2170	8953	3691	8836	5212	15
9 0	9261	9386	9138	0950	9015	2515	8892	4079	8769	5643	81 0
15	9220	9645	9090	1252	8960	2859	8830	4467	8700	6074	45
30	9177	9903	9040	1553	8903	3204	8766	4854	8629	6505	30
45	9133	1.0161	8989	1854	8844	3548	8700	5241	8556	6935	15
10 0	9088	0419	8937	2155	8785	3892	8633	5628	8481	7365	80 0
15	5.9042	1.0677	6.8883	1.2456	7.8723	1.4235	8.8564	1.6015	9.8404	1.7794	45
30	8995	0934	8728	2756	8660	4579	8493	6401	8325	8224	30
45	8947	1191	8772	3057	8596	4922	8421	6787	8245	8652	15
11 0	8898	1449	8714	3357	8530	5265	8346	7173	8163	9081	79 0
15	8847	1705	8655	3656	8463	5607	8271	7558	8079	9509	45
30	8795	1962	8595	3956	8394	5949	8193	7943	7992	9937	30
45	8743	2219	8533	4255	8324	6291	8114	8328	7905	2.0364	15
12 0	8689	2475	8470	4554	8252	6633	8033	8712	7815	0791	78 0
15	8634	2731	8406	4852	8178	6974	7951	9096	7723	1218	45
30	8578	2986	8341	5151	8104	7315	7867	9480	7630	1644	30
45	5.8521	1.3242	6.8274	1.5449	7.8027	1.7656	8.7781	1.9863	9.7534	2.2070	15
13 0	8462	3497	8206	5747	7950	7996	7693	2.0246	7437	2495	77 0
15	8403	3752	8137	6044	7870	8336	7604	0628	7338	2920	45
30	8342	4007	8066	6341	7790	8676	7513	1010	7237	3345	30
45	8281	4261	7994	6638	7707	9015	7421	1392	7134	3769	15
14 0	8218	4515	7921	6935	7624	9354	7327	1773	7030	4192	76 0
15	8154	4769	7846	7231	7538	9692	7231	2154	6923	4615	45
30	8089	5023	7770	7527	7452	2.0030	7133	2534	6815	5038	30
45	8023	5276	7693	7822	7364	0368	7034	2914	6705	5460	15
15 0	7956	5529	7615	8117	7274	0706	6933	3294	6593	5882	75 0
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		Course.

TABLE 3.—*Traverse*—Continued.

Course.	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
° ′											° ′
15 15	5.7887	1.5782	6.7535	1.8412	7.7183	2.1042	8.6831	2.3673	9.6479	2.6303	74 45
30	7818	6034	7454	8707	7090	1379	6727	4051	6363	6724	30
45	7747	6286	7372	9001	6996	1715	6621	4430	6246	7144	15
16 0	7676	6538	7288	9295	6901	2051	6514	4807	6126	7564	74 0
15	7603	6790	7203	9588	6804	2386	6404	5185	6005	7983	45
30	7529	7041	7117	9881	6706	2721	6294	5561	5882	8402	30
45	7454	7292	7030	2.0174	6606	3056	6181	5938	5757	8820	15
17 0	7378	7542	6941	0466	6504	3390	6067	6313	5630	9237	73 0
15	7301	7792	6851	0758	6402	3723	5952	6689	5502	9654	45
30	7223	8042	6760	1049	6297	4056	5835	7064	5372	3.0071	30
45	5.7144	1.8292	6.6668	2.1341	7.6192	2.4389	8.5716	2.7438	9.5240	3.0486	15
18 0	7063	8541	6574	1631	6085	4721	5595	7812	5106	0902	72 0
15	6982	8790	6479	1921	5976	5053	5473	8185	4970	1316	45
30	6899	9038	6383	2211	5866	5384	5349	8557	4832	1730	30
45	6816	9286	6285	2501	5754	5715	5224	8930	4693	2144	15
19 0	6731	9534	6186	2790	5641	6045	5097	9301	4552	2557	71 0
15	6645	9781	6086	3078	5527	6375	4968	9672	4409	2969	45
30	6558	2.0028	5985	3366	5411	6705	4838	3.0043	4264	3381	30
45	6471	0275	5882	3654	5294	7033	4706	0413	4118	3792	15
20 0	6382	0521	5778	3941	5175	7362	4572	0782	3969	4202	70 0
15	5.6291	2.0767	6.5673	2.4228	7.5055	2.7689	8.4437	3.1151	9.3819	3.4612	45
30	6200	1012	5567	4515	4934	8017	4300	1519	3667	5021	30
45	6108	1257	5459	4800	4811	8343	4162	1886	3514	5429	15
21 0	6015	1502	5351	5086	4686	8669	4022	2253	3358	5837	69 0
15	5920	1746	5241	5371	4561	8995	3881	2619	3201	6244	45
30	5825	1990	5129	5655	4433	9320	3738	2985	3042	6650	30
45	5729	2233	5017	5939	4305	9645	3593	3350	2881	7056	15
22 0	5631	2476	4903	6222	4175	9969	3447	3715	2718	7461	68 0
15	5532	2719	4788	6505	4043	3.0292	3299	4078	2554	7855	45
30	5433	2961	4672	6788	3910	0615	3149	4442	2388	8268	30
45	5.5332	2.3203	6.4554	2.7070	7.3776	3.0937	8.2998	3.4804	9.2220	3.8671	15
23 0	5230	3414	4435	7351	3640	1258	2845	5166	2050	9073	67 0
15	5127	3685	4315	7632	3503	1580	2691	5527	1879	9474	45
30	5024	3925	4194	7912	3365	1900	2535	5887	1706	9875	30
45	4919	4165	4072	8192	3225	2220	2378	6247	1531	4.0275	15
24 0	4813	4404	3948	8472	3084	2539	2219	6606	1355	0674	66 0
15	4706	4643	3823	8750	2941	2858	2059	6965	1176	1072	45
30	4598	4882	3697	9029	2797	3175	1897	7322	0996	1469	30
45	4489	5120	3570	9306	2651	3493	1733	7679	0814	1866	15
25 0	4378	5357	3442	9583	2505	3809	1568	8036	0631	2262	65 0
15	5.4267	2.5594	6.3312	2.9800	7.2356	3.4125	8.1401	3.8391	9.0446	4.2657	45
30	4155	5831	3181	3.0136	2207	4441	1233	8746	0259	3051	30
45	4042	6067	3049	0411	2056	4756	1063	9100	0070	3445	15
26 0	3928	6302	2916	0686	1904	5070	0891	9453	8.9879	3837	64 0
15	3812	6537	2781	0960	1750	5383	0719	9806	9687	4229	45
30	3696	6772	2645	1234	1595	5696	0644	4.0158	9493	4620	30
45	3579	7006	2509	1507	1438	6008	0368	0509	9298	5010	15
27 0	3460	7239	2370	1779	1281	6319	0191	0859	9101	5399	63 0
15	3341	7472	2231	2051	1121	6630	0012	1209	8902	5787	45
30	3221	7705	2091	2322	0961	6940	7.9831	1557	8701	6175	30
45	5.3099	2.7937	6.1949	3.2593	7.0799	3.7249	7.9649	4.1905	8.8499	4.6561	15
28 0	2977	8168	1806	2863	0636	7558	9465	2252	8295	6947	62 0
15	2853	8399	1662	3132	0471	7866	9280	2599	8089	7332	45
30	2729	8630	1517	3401	0305	8173	9094	2944	7882	7716	30
45	2604	8859	1371	3669	0138	8479	8905	3289	7673	8099	15
29 0	2477	9089	1223	3937	6.9970	8785	8716	3633	7462	8481	61 0
15	2350	9317	1075	4203	9800	9090	8525	3976	7250	8862	45
30	2221	9545	0925	4470	9628	9394	8332	4318	7036	9242	30
45	2092	9773	0774	4735	9456	9697	8138	4659	6820	9622	15
30 0	1962	3.0000	0622	5000	9282	4.0000	7942	5000	6603	5.0000	60 0
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		Course.

TABLE 3.—*Traverse*—Continued.

Course.	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
° ′											° ′
30 15	5.1830	3.0226	6.0468	3.5264	6.9107	4.0302	7.7745	4.5340	8.6384	5.0377	59 45
30	1698	0452	0314	5528	8930	0603	7547	5678	6163	0754	30
45	1564	0678	0158	5791	8753	0903	7347	6016	5941	1129	15
31 0	1430	0902	0002	6053	8573	1203	7145	6353	5717	1504	59 0
15	1295	1126	5.9844	6314	8393	1502	6942	6690	5491	1877	45
30	1158	1350	9685	6575	8211	1800	6738	7025	5264	2250	30
45	1021	1573	9525	6835	8028	2097	6532	7359	5035	2621	15
32 0	0883	1795	9363	7094	7844	2394	6324	7693	4805	2992	58 0
15	0744	2017	9201	7353	7658	2689	6116	8025	4573	3361	45
30	0603	2238	9037	7611	7471	2984	5905	8357	4339	3730	30
45	5.0462	3.2458	5.8873	3.7868	6.7283	4.3278	7.5694	4.8688	8.4104	5.4097	15
33 0	0320	2678	8707	8125	7094	3571	5480	9018	3867	4464	57 0
15	0177	2898	8540	8381	6903	3862	5266	9346	3629	4829	45
30	0033	3116	8372	8636	6711	4155	5050	9674	3389	5194	30
45	4.9888	3334	8203	8890	6518	4446	4832	5.0001	3147	5557	15
34 0	9742	3552	8033	9144	6323	4735	4613	0327	2904	5919	56 0
15	9595	3768	7861	9396	6127	5024	4393	0652	2659	6280	45
30	9448	3984	7689	9648	5930	5312	4171	0977	2413	6641	30
45	9299	4200	7515	9900	5732	5600	3948	1300	2165	7000	15
35 0	9149	4415	7341	4.0150	5532	5886	3724	1622	1915	7358	55 0
15	4.8998	3.4629	5.7165	4.0400	6.5331	4.6172	7.3498	5.1943	8.1664	5.7715	45
30	8847	4842	6988	0649	5129	6456	3270	2263	1412	8070	30
45	8694	5055	6810	0897	4926	6740	3042	2582	1157	8425	15
36 0	8541	5267	6631	1145	4721	7023	2812	2901	0902	8779	54 0
15	8387	5479	6451	1392	4516	7305	2580	3218	0644	9131	45
30	8231	5689	6270	1638	4309	7586	2347	3534	0386	9482	30
45	8075	5899	6088	1883	4100	7866	2113	3849	0125	9832	15
37 0	7918	6109	5904	2127	3891	8145	1877	4163	7.9864	6.0182	53 0
15	7760	6318	5720	2371	3680	8424	1640	4476	9600	0529	45
30	7601	6526	5535	2613	3468	8701	1402	4789	9335	0876	30
45	4.7441	3.6733	5.5348	4.2855	6.3255	4.8977	7.1162	5.5100	7.9069	6.1222	15
38 0	7281	6940	5161	3096	3041	9253	0921	5410	8801	1566	52 0
15	7119	7146	4972	3337	2825	9528	0679	5718	8532	1909	45
30	6956	7351	4783	3576	2609	9801	0435	6026	8261	2251	30
45	6793	7555	4592	3815	2391	5.0074	0199	6333	7988	2592	15
39 0	6629	7759	4406	4052	2172	0346	6.9943	6639	7715	2932	51 0
15	6464	7962	4207	4289	1951	0616	9695	6943	7439	3271	45
30	6297	8165	4014	4525	1730	0886	9446	7247	7162	3608	30
45	6131	8366	3819	4761	1507	1155	9196	7550	6884	3944	15
40 0	5963	8567	3623	4995	1284	1423	8944	7851	6604	4279	50 0
15	4.5794	3.8767	5.3426	4.5229	6.1059	5.1690	6.8691	5.8151	7.6323	6.4612	45
30	5624	8967	3228	5461	0832	1956	8437	8450	6041	4945	30
45	5454	9166	3030	5693	0605	2221	8181	8748	5756	5276	15
41 0	5283	9364	2830	5924	0377	2485	7924	9045	5471	5606	49 0
15	5110	9561	2629	6154	0147	2748	7666	9341	5184	5935	45
30	4937	9757	2427	6383	5.9916	3010	7406	9636	4896	6262	30
45	4763	9953	2224	6612	9685	3271	7145	9929	4606	6588	15
42 0	4589	4.0148	2020	6839	9452	3530	6883	6.0222	4314	6913	48 0
15	4413	0342	1815	7066	9217	3789	6620	0513	4022	7237	45
30	4237	0535	1609	7291	8982	4047	6355	0803	3728	7559	30
45	4.4059	4.0728	5.1403	4.7516	5.8746	5.4304	6.6089	6.1092	7.3432	6.7880	15
43 0	3881	0920	1195	7740	8508	4560	5822	1380	3135	8200	47 0
15	3702	1111	0986	7963	8270	4815	5553	1666	2837	8518	45
30	3522	1301	0776	8185	8030	5068	5284	1952	2537	8835	30
45	3342	1491	0565	8406	7789	5321	5013	2236	2236	9151	15
44 0	3160	1680	0354	8626	7547	5573	4741	2519	1934	9466	46 0
15	2978	1867	0141	8845	7304	5823	4467	2801	1630	9779	45
30	2795	2055	4.9928	9064	7060	6073	4193	3082	1325	7.0091	30
45	2611	2241	9713	9281	6815	6321	3917	3361	1019	0401	15
45 0	2426	2426	9497	9497	6569	6569	3640	3640	0711	0711	45 0
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
	Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		Dist. 10.		Course.

TABLE 4.—*Condensed traverse table for cruising.*

Degrees.	Latitude.	Departure.		Degrees.	Latitude.	Departure.	
0	1.000	0.000	90	23	0.920	0.391	67
1	1.000	.017	89	24	.913	.497	66
2	.999	.035	88	25	.906	.423	65
3	.999	.052	87	26	.899	.438	64
4	.998	.070	86	27	.891	.454	63
5	.996	.087	85	28	.883	.470	62
6	.995	.104	84	29	.875	.485	61
7	.992	.122	83	30	.866	.500	60
8	.990	.139	82	31	.857	.515	59
9	.988	.156	81	32	.848	.530	58
10	.985	.174	80	33	.839	.545	57
11	.982	.191	79	34	.829	.559	56
12	.978	.208	78	35	.819	.574	55
13	.974	.225	77	36	.809	.588	54
14	.970	.242	76	37	.799	.602	53
15	.966	.259	75	38	.788	.616	52
16	.961	.276	74	39	.777	.629	51
17	.956	.292	73	40	.766	.643	50
18	.951	.309	72	41	.755	.656	49
19	.946	.326	71	42	.743	.669	48
20	.940	.342	70	43	.731	.682	47
21	.934	.358	69	44	.719	.695	46
22	.927	.375	68	45	.707	.707	45
	Departure.	Latitude.	Degrees.		Departure.	Latitude.	Degrees.

TABLE 5.—*Surface measuring on slopes.*

[Increase of distance to be added to one 66′ chain of surface measurement to give one chain of horizontal measurement. Approximate; for use in cruising.]

Slope.	Grade.	Equivalent vertical angle.	Increase of distance per 66′ chain (exsecant).[1]
	Per cent.	°	*Links.*
Level			
Gentle	5	3.0	0.1
	10	5.5	.5
	15	8.5	1.1
Moderate	20	11.5	2.0
	30	16.5	4.4
	40	22.0	7.8
Steep	50	26.5	11.7
	60	31.0	16.6
	70	35.0	22.1
Very steep	80	38.5	28.0
	90	42.0	34.6
	100	45.0	41.4

The per cent of grade is determined by grademeter or hypsometer.
Vertical angles are read by clinometer, Abney level, or transit.

[1] The exsecant is a ratio of links per 100 links (=1 chain), and therefore the figures in this column also show feet per 100 feet, or yards per 100 yards, etc.

BLAZES AND MARKS ON TREES.

Trees should never be blazed nor marked upon random or trial lines nor upon other preliminary or temporary surveys, where they may be misleading in the future.

A survey *line* is *blazed* in order that it may be located or retraced between corners which are at each end of the line. *Corners* and *intersections* are witnessed by *marks*. Thus the ax scars used in surveying may be either blazes or marks, one term being applied to a line and the other to a point. In some books on surveying these terms have been used interchangeably or carelessly, but it is better to make the distinction in the Forest Service, where surveying is done for so many different purposes.

A survey *line* is *blazed* in the following manner: Trees which are on the line are blazed fore and back, meaning that the surveyor took a foresight when running toward the tree and a backsight when running away from it, on the same straight line. Such a tree is called a line tree and is spoken of as being line-blazed. Trees standing near the line, within 50 links on either side, are blazed on two sides quartering toward the line.

Blazes for roads need not be permanent because the subsequent construction of the highway fixes the line. Property lines should be permanently blazed—that is, through the bark to the wood, leaving a scar which may be recognized or found as long as the tree stands. Blazes should be the width of an ax blade, about 6 inches long, and placed breast high. When it is probable that the blazes will be used when there is deep snow upon the ground, they should be placed high enough to be seen, or the trees may be given a

second blazing at a higher point after the deep snow renders this convenient.

It is often desirable, as in the case of trails, that Forest Service blazes should be distinguished from land office blazes or from private surveys, and, therefore, a distinctive blaze has been adopted for the Forest Service. This is the width of an ax blade, about 6 inches long, with a horizontal notch at the top of the scar.

The Forest Service has also adopted a distinctive *mark* to indicate the *intersection* of one of its lines with a land office line and to show the approximate distance to the nearest land office corner. Thus, when a road or trail crosses a section line a tree may be marked in such a manner that any Forest officer may recognize it, and will know the direction and approximate distance to the nearest section or quarter-section corner. This mark is made in the following manner: A tree near the point of intersection is barked to the wood, about 8 by 10 inches, on the side facing the corner. A letter C with horizontal crossbars is then scribed upon the scar. A horizontal bar will indicate that the distance to the corner is about 10 chains, and each half bar will indicate a distance of about 5 chains. For example, the intersection marks may read as follows:

About 5 chains to corner. About 10 chains to corner. About 15 chains to corner. About 20 chains to corner. About 25 chains to corner.

It will sometimes happen that an intersection tree can not be marked facing the corner and at the same time have the mark visible from the trail or road. In such cases the mark will face the corner and an X will be cut, through the bark, on the side toward the highway. The letter X is a recognized symbol, indicating the crossing of lines or to indicate that a trail crosses a stream at this point. It is often useful in the latter case when there is snow on the ground, as it shows that the stream must be forded, and that the trail will be found on the other side. It will, therefore, be used for both purposes mentioned, and its meaning will never be misunderstood. The letter Y is often used to indicate that the trail forks at this point, and is useful when there is snow upon the ground.

It will frequently happen that a land-office corner will be accidentally found, and the distance from it to the point of intersection will be immediately determined by pacing. This is sufficiently accurate to warrant the marking of an intersection witness tree, as stated above, as the distance is only presumed to be approximate. Whether the line is paced or measured, the ranger will make a record in his notebook, describing the land-office corner and the distance to the intersection, and the marks which he placed at that point. The following is a specimen of such a record:

SPECIMEN RECORD.

October 4, 1912, 10 a. m. I found the quarter-corner between sections 15 and 16, T. 8 N., R. 21 W. Both witness trees were standing, but the stake had fallen over. The rotted point was found in the ground and I reset the stake above it, placing a mound of stones about it to hold it in position. From this corner I paced south, following the original blazes, 23 chains, to the intersection

of the new Forest Service trail between Wild Cat Ranger Station and Alta Lookout Point. Established for witness red fir 20 inches in diameter, on north side of trail, 40 links distant from intersection, marked € on north side and X on south side.

October 4, 6 p. m. Made a record of the above information on the atlas sheet.

JOHN R. UNDERWOOD,
Ranger.

It is important that any geographic information which may be used to correct the atlas sheets, and thus lead to the preparation of accurate forest maps, should be placed upon the sheets which are kept for that purpose by each forest officer. All of such corrections or additional data should be transmitted to the supervisor as he may require them, but certainly in ample time for him to include them in the corrected folio which he sends to the Forester on February 1 of each year.

Other marks used by the Forest Service are described under "Ranger station surveys" and "Forest homestead surveys."

FIELD NOTES.

Notes of survey should show exactly what was done in the field, including the errors of courses or measurements. In resurveying lines, it is no reflection on the survey party if it does not "check up" exactly, but it is rather expected that a trial or "random line" will not strike a corner nor the measurement prove exactly as "returned" by the original surveyor. It is important, however, to know what the error or difference is discovered to be.

When a notebook contains the field notes of only one survey, the purpose of which the survey was made should be plainly marked on the cover as well as on

the first page. If it contains the notes of more than one survey, the title of a survey should be written at the top of each page, and the book should be indexed on the first page. Each book should be numbered and paged. When the notes for a survey do not follow in regular order in a notebook be sure to refer to the page where the continuation can be found and at that point refer back by page number to the former notes.

It is a good plan to make numerous explanatory sketches on the right-hand pages of the notebooks, leaving nothing to the memory, and particularly the direction of the flow of streams should be shown by arrows. If the surveyor will always imagine that he might stop work at any moment, and some one else may be obliged to continue the survey, and will keep his notes so clearly that this would be easy, then they are apt to be a reliable record. Never erase notes—cross them out and mark them "abandoned."

Field notes should never be crowded into a notebook or be written as a continuous recital, but should be tabulated clearly that they may be readily platted by any surveyor or draftsman. A good form for keeping notes is here shown.

SPECIMEN NOTES.

..... National Forest.

Resurvey of east boundary of sec. 24, T. 19 N., R. 14 E.

June 16, 1912.

Weather clear.

I corrected both *aneroids* at the benchmark at . . . . which has an elevation of . . . . ft.

Made camp 5.30 p. m. Sec. 24, T. 19 N., R. 14 E.

7 p. m. Camp barometer reads 4,850′.

Field barometer reads 4,860′.

At 9 p. m. observed *Polaris* and find the variation at camp to be 19° east.

June 17, 1912.
Weather clear.

7 a. m. Camp barometer 4,850′.
Field barometer 4,860′.

Resurvey of east boundary of sec. 24, T. 19 N., R. 14 E., in the . . . . . National Forest. The *original survey* was made in 1872, with variation 18½° east. Allowing for the reported increase, the variation should be about 19° 05′.

		Elev.
	From the southeast corner of sec. 24	4,780′
	Ran *north*, var. 19° east.	
10.00 ch.	near 36″ yellow pine	4,720′
20.00	in thicket of firs	4,680′
24.50	creek, 4 links wide, flows SW	4,660′
30.00	at foot of steep slope	4,740′
40.00	on steep sidehill, SE	4,920′
40.23	to a point 15 links west of ¼ corner on east side sec. 24.	
	On this line the original blazes were almost obliterated, and I made new blazes.	
	From the ¼ corner on east side of sec. 24.	
	Ran *north*, var. 19° east.	
10.00 ch.	enter burned area	5,050′
13.60	top of hill NE. and SW	5,120′

From this point I take *vertical angles* on some high points in unsurveyed T. 19 N., R. 15 E., as follows:

	Elev..
N. 24¼ E. 3 miles, vertical angle 1½°	5,545′
N. 37¼ E. 2¼ miles, vertical angle ¼°	5,179′
N. 89° E. ? miles, vertical angle 1¾°	
S. 43½ E. 4 miles, vertical angle 1°	5,503′
S. 10° E. 3¼ miles, vertical angle ¾°	5,355′

thence continue *north*.

20.00	heavy litter	5,075′
27.30	leave burn	
30.00	in good reproduction yellow pine	4,900′
39.85	to a point 20 links east of NE. cor. of sec. 24. Witness trees standing, but stake almost destroyed. Set new stake with the proper marks and U. S. F. S. on SW. side	4,850′

etc., etc.

7 p. m. Camp barometer, 4,870′.
Field barometer, 4,880′.

ROAD, STREAM, OR SUMMIT MEANDERS.

The method of keeping meander notes differs from the above. Each course begins a new tally, and any intermediate distances are entered in a third column. The second column may then be added to determine the total distance surveyed, viz:

..... National Forest.
Meanders in unsurveyed T. 19 N., R. 15 E.
June 18, 1912.
Weather cloudy.

7 a. m. Camp barometer, 4,880′.
Field barometer, 4,890′.
From a point 13.60 ch. north of ¼ cor. on the east side of sec. 24.
Ran *along summit*, var. 19° east.

N. 24	E. 9.00 ch.	at 6.00 leave burn	5,200′
N. 39½	E. 17.50	at 3.00 trail N. and S	5,125′
N. 48¼	E. 11.20		5,175′
S. 86	E. 14.60	highest point on summit	5,320′

At this point the summit divides; one branch bearing SE. and the other SW.
Continuing the meanders:
Ran *down gulch*, between the two divides.
Var. 19° east.

N. 89	E. 18.00 ch.	spring	5,150′
N. 75	E. 15.00	meadow, 2 acres	5,025′
S. 83	E. 4.00	falls, 10 feet	4,975′
N. 80	E. 22.20	at 18.00 small tributary from the south	4,900′
N. 86	E. 9.00	at 2.30 the notice of the Morning Star mining claim bears S. 1.50; at 3.40 mining cabin	4,875

etc., etc.

TABLE 6.—*Difference of altitude between the "station" occupied by the surveyor, of which the altitude is known, and a higher distant object whose altitude is desired.*

[Difference of altitude in feet—add to station altitude.]

Vertical angle above a level line.	Distance to object, in miles.									
	1	2	3	4	5	6	7	8	9	10
0°00′	5	7	10	14	19	25	33	41	51	62
15	28	53	79	106	134	163	194	225	258	292
30	51	99	148	198	249	301	356	410	466	523
45	74	145	217	290	365	440	517	594	673	753
1°00′	97	191	286	383	480	578	678	778	880	984
15	120	237	356	475	595	716	839	963	1,088	1,214
30	143	283	425	567	710	855	1,001	1,147	1,295	1,445
45	166	330	494	659	826	993	1,162	1,332	1,503	1,675
2°00′	189	376	563	752	941	1,131	1,324	1,516	1,710	1,906
15	212	422	632	844	1,056	1,270	1,485	1,701	1,918	2,137
30	235	468	702	936	1,172	1,408	1,647	1,885	2,126	2,367
45	259	514	771	1,028	1,287	1,547	1,808	2,070	2,334	2,598
3°00′	282	560	840	1,121	1,403	1,685	1,970	2,255	2,541	2,829
15	305	607	909	1,213	1,518	1,824	2,132	2,440	2,749	3,060
30	328	653	979	1,306	1,634	1,963	2,294	2,625	2,957	3,291
45	351	699	1,048	1,398	1,749	2,101	2,455	2,810	3,166	3,523
4°00′	374	745	1,118	1,491	1,865	2,240	2,617	2,995	3,374	3,754
15	397	792	1,187	1,583	1,981	2,379	2,780	3,180	3,582	3,986
30	420	838	1,257	1,676	2,097	2,518	2,942	3,365	3,791	4,217
45	444	884	1,326	1,769	2,213	2,657	3,104	3,551	4,000	4,449
5°00′	467	931	1,396	1,862	2,329	2,797	3,267	3,737	4,208	4,681
15	490	977	1,466	1,955	2,445	2,936	3,429	3,922	4,418	4,914
30	513	1,024	1,535	2,048	2,561	3,075	3,592	4,108	4,627	5,146
45	537	1,070	1,605	2,141	2,677	3,215	3,755	4,294	4,836	5,379
6°00′	560	1,117	1,675	2,234	2,794	3,355	3,918	4,481	5,046	5,612
15	583	1,164	1,745	2,327	2,910	3,495	4,081	4,667	5,255	5,845
30	607	1,210	1,815	2,420	3,027	3,634	4,244	4,854	5,465	6,078
45	630	1,257	1,885	2,514	3,144	3,775	4,407	5,040	5,675	6,311
7°00′	653	1,304	1,955	2,607	3,261	3,915	4,571	5,227	5,886	6,545
15	677	1,350	2,025	2,701	3,378	4,055	4,735	5,415	6,096	6,779
30	700	1,397	2,095	2,795	3,595	4,196	4,899	5,602	6,307	7,013
45	724	1,444	2,166	2,888	3,612	4,337	5,063	5,790	6,518	7,248
8°00′	747	1,491	2,236	2,982	3,729	4,477	5,227	5,977	6,729	7,483
15	771	1,538	2,307	3,076	3,847	4,618	5,392	6,166	6,941	7,718
30	794	1,585	2,377	3,170	3,964	4,760	5,557	6,354	7,153	7,953
45	818	1,632	2,448	3,265	4,082	4,901	5,722	6,542	7,365	8,189

TABLE 6.—*Difference of altitude between the "station" occupied by the surveyor, of which the altitude is known, and a higher distant object whose altitude is desired*—Continued.

[Difference of altitude in feet—add to station altitude.]

Vertical angle above a level line.	Distance to object, in miles.									
	1	2	3	4	5	6	7	8	9	10
9°00′	841	1,680	2,519	3,359	4,200	5,043	5,887	6,731	7,577	8,425
15	865	1,727	2,590	3,454	4,319	5,185	6,053	6,920	7,790	8,661
30	889	1,774	2,661	3,548	4,437	5,327	6,218	7,109	8,003	8,898
45	912	1,821	2,732	3,643	4,556	5,469	6,384	7,299	8,217	9,135
10°00′	936	1,869	2,803	3,738	4,674	5,611	6,550	7,489	8,430	9,372
15	960	1,917	2,874	3,833	4,793	5,754	6,717	7,679	8,644	9,610
30	984	1,964	2,946	3,928	4,912	5,897	6,883	7,870	8,858	9,848
45	1,007	2,012	3,017	4,024	5,031	6,040	7,050	8,061	9,073	10,087
11°00′	1,031	2,060	3,089	4,119	5,151	6,183	7,217	8,252	9,288	.....
15	1,055	2,108	3,161	4,215	5,270	6,327	7,385	8,443	9,504	.....
30	1,079	2,155	3,233	4,311	5,390	6,470	7,553	8,635	9,719	.....
45	1,103	2,204	3,305	4,407	5,510	6,615	7,721	8,827	9,935	.....
12°00′	1,127	2,252	3,377	4,503	5,631	6,759	7,839	9,019	.....	.....
15	1,151	2,300	3,449	4,600	5,751	6,904	8,058	9,212	.....	.....
30	1,176	2,348	3,522	4,696	5,872	7,048	8,227	9,405	.....	.....
45	1,200	2,397	3,594	4,793	5,993	7,194	8,396	9,599	.....	.....
13°00′	1,224	2,445	3,667	4,890	6,114	7,339	8,566	.....	.....	.....
15	1,248	2,494	3,740	4,987	6,235	7,485	8,736	.....	.....	.....
30	1,273	2,542	3,813	5,084	6,357	7,631	8,906	.....	.....	.....
45	1,297	2,591	3,886	5,182	6,479	7,777	9,077	.....	.....	.....
14°00′	1,321	2,640	3,959	5,280	6,601	7,924	.....	.....	.....	.....
15	1,346	2,689	4,033	5,378	6,724	8,071	.....	.....	.....	.....
30	1,371	2,738	4,107	5,476	6,847	8,218	.....	.....	.....	.....
45	1,395	2,787	4,180	5,574	6,970	8,366	.....	.....	.....	.....
15°00′	1,420	2,837	4,254	5,673	7,093	.....	.....	.....	.....	.....
15	1,444	2,886	4,327	5,771	7,216	.....	.....	.....	.....	.....
30	1,469	2,935	4,402	5,870	7,339	.....	.....	.....	.....	.....
45	1,494	2,985	4,477	5,970	7,463	.....	.....	.....	.....	.....

This table is corrected for earth curvature, refraction, and the height of the instrument used at the station (4½ feet).

ELEVATIONS FROM VERTICAL ANGLES.

When the distance to a mountain or other object is known its elevation above the surveyor may be determined. A vertical angle is measured with a clinometer or clinometer-compass, and the difference in elevation can be determined from the table. Information of this character assists greatly in the preparation of a map, and this method should be used when a peak is inaccessible or not likely to be occupied during the present survey. If both the distance and elevation of a peak are known, and the surveyor desires the elevation of the station which he is then occupying, this process is easily reversed. The table is prepared to miles of distance, and if intermediate fractional miles are needed the ratio may be interpolated.

The method of determining the distance of a peak or other salient topographic point is illustrated in the various plane-table methods. If compass sights are taken from two or more known points the intersections may be platted with a protractor or computed.[1]

---

[1] The following is the method of computing the sides of a triangle when two angles and one side are known: The angle opposite the known side is equal to 180° minus the sum of the two known angles. The sine of an angle is the same as its departure (in the traverse table) for distance 1. A and B represent the two known angles and their distance apart; C is the opposite angle:

Then:

$$\frac{\text{Distance } AB \times \text{sine of angle } B}{\text{Sine of angle } C} = \text{distance } AC$$

Or:

$$\frac{\text{Distance } AB \times \text{sine of angle } A}{\text{Sine of angle } C} = \text{distance } BC$$

The traverse table, distance 1, being the same as a table of natural cosines and sines, may be used to change a slope measurement to a horizontal measurement, and also get the difference in elevation. Thus a distance of 10.00 chains up or down a 7° slope would represent 9.92 chains on the level, and 1.22 chains rise or fall. The same method is used in reducing stadia measurements.

TYING IN.

It is frequently necessary to make surveys of ranger stations or for timber sales in areas which have not been previously surveyed or mapped. It is imperative that some connection should be surveyed between the nearest or most convenient established point and the initial point of the survey which is to be made. Otherwise the survey will not determine the location of the area under consideration. The nature of the country and the distance necessary to be run will suggest which of the following methods may be employed:

(1) Measure a line north, south, east, or west to intersect a Government survey line. Then tie to the nearest corner, quarter corner, meander corner, milepost, grant corner, or other point which is of official record.

(2) Or run a traverse (meander) over a road, trail, open or easy country to such points.

(3) Or if no land office surveys have been made nearer than, say, 5 miles, but there is a Geological Survey sheet, then tie to a bench mark, triangulation station, forks of a road, forks of a stream which has not changed its bed, or a house which is shown on the sheet. Accompany your report with a tracing or description which will show unmistakably the point used. If you tie to a mineral monument or to some corner of a patented mining claim, give a clear description.

(4.) Or if no official surveys have been made within practicable distance, proceed as follows: Establish and witness a permanent monument, marked F S M. This may be at the initial point of your survey. From

this point run a traverse to some outlook where compass or plane-table bearings may be taken on a number of peaks or other definite landmarks which may be visible. Give their estimated distances. State approximately what unsurveyed section the land would be in, or its latitude and longitude. The map accompanying such a survey should show any divide, stream, or trail in the immediate vicinity, and particularly the name of the watershed.

RANGER STATION SURVEYS.

When the lands have been surveyed by the General Land Office and the corners can be located, the plat only need be submitted, showing the subdivisions desired for a ranger station. Where lots occur their numbers should be shown on the plat. No other description is necessary. The determination of the correct subdivisions must not be left to conjecture. The land office corners should be located and the necessary lines carefully run in every case when there is the least doubt as to what forties or tens should be recommended for withdrawal.

When the lands are unsurveyed, or the corners of the Government survey can not be located, the actual boundary lines must be surveyed and marked, and field notes, description, and a plat must be prepared, all in accordance with the following instructions:

Three kinds of permanent points of identification will be established—*Forest Service Monuments*, to which the ranger station surveys, and possibly future homestead or timber surveys, will be tied by bearing and distance;

corners, which will be set up at each angle in the boundary; and *witnesses*, to which, whenever possible, each monument and corner will be tied.

Forest Service Monuments.—The object of these monuments is explained under the subject "Tying in." They will be similar to the mineral monuments of a mining district. They should, if possible, be immovable and durable, and easy to locate at any future time from the field notes of the survey. A large bowlder or a built-up stone monument will serve the purpose, or a sound tree of long-lived species. Where there are no trees a wooden post may be used. Monuments will be marked F S M The *witnesses* for a monument should be permanent objects from which at least two cross bearings can be taken to locate the monument in the future if necessary. They will be marked $\frac{M}{W}$.

At each angle in the boundary of a *ranger station* a durable *corner* will be established similar to those of the land-office surveys. Each corner post or stone will be marked near its top with the letter R and below this the number of the angle at which the corner is set, beginning with the initial post as number 1 and counting on in regular sequence around the boundary in the direction of the survey. Thus the monument of the third corner will be marked $\frac{R}{3}$.

At least two *witnesses* will be made near each corner, and will be marked with the letter W and the number of the corner, thus: $\frac{W}{3}$.

If the monument is established at the initial point of a survey, and is therefore also corner number 1, it will bear both monument and corner markings, thus: F S M $\frac{R}{1}$ The witnesses will then bear the letters $\frac{M}{W}$ with the figure 1 beneath, thus: $\frac{M}{W}$ 1

The surveyor will depend largely on his common sense and skill in selecting trees or prominent rocks in the best positions for witnesses. Frequently the corners can be established near good witnesses without diminishing the value of the station. Usually the witnesses should not be more than 3 chains from a corner—the nearer the better, but they should be inside the boundary if possible.

Where the boundary line of the ranger station passes through timber, the line should be plainly blazed in the manner described on page 41.

The instructions regarding field notes (p. 44) must be followed. A good form for keeping them is here shown:

SPECIMEN NOTES.

..... National Forest.

WILDCAT RANGER STATION.

T. 25 N., R. 8 E., Section ....., ... Meridian. Number ..... List ..... Area, 33.63 acres.

June 15, 1912.
Weather cloudy.

Variation.—This survey was made with a Forest Service standard compass. Variation, 11° 30′ E., was obtained by retracement of east line of Section 36, T. 25 N., R. 7 E. The local land office recommends using a variation of 11° to 11° 40′ in this vicinity.

Forest Service Monument.—Consists of a bowlder 7′×6′×3′ above ground, situated on the left bank of Wildcat Creek, 7 chains downstream from the juncture of the north and east forks, 70 links from the water's edge, at right angles to the stream. F S M cut on the

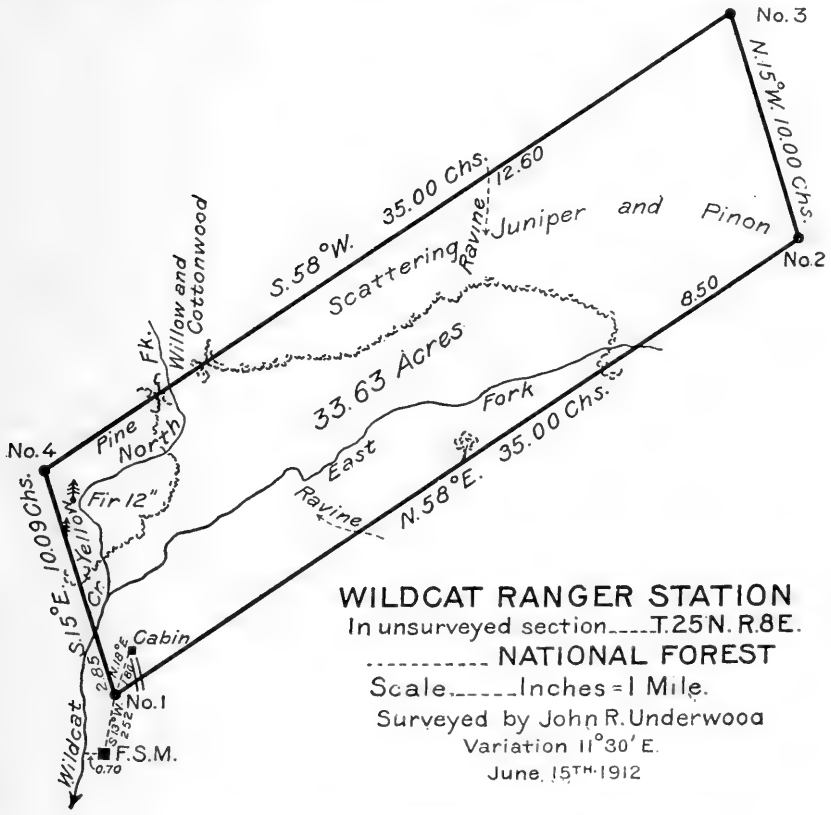


FIG. 11.—Ranger station plat.

highest point of the rock, whence a yellow pine 16 inches in diameter bears N. 16° E., 73 links distant, marked $\frac{M}{W}$ in blaze. Lyon Mountain bears S. 31° 30′ W. Tiger Mountain bears N. 28° 30′ W. Rock ledge bears S. 54° W., 47 links distant, marked $\frac{M}{W}$

Beginning at corner No. 1, a limestone 30″×9″×5″ set in mound of stones and chiseled $\frac{R}{1}$

Forest Service Monument above described bears S. 13° W., 252 links distant.

The SW. corner of the ranger's cabin, built in 1905, bears N. 18° E., 180 links distant.

A yellow pine, 12 inches diameter, bears east, 298 links distant marked $\frac{W}{1}$

Thence N. 58° E.

1.20 chs. road, N. and S.
12.40 ravine, course NW.
17.80 leaning scrubby pinon 16 inches diameter.
25.00 enter scattering juniper and pinon.
26.50 East Fork Wildcat Creek flows N. 89° W.
35.00 corner No. 2, a juniper post 5′×4″×4″ in mound of gravel and earth, at foot of slope, marked $\frac{R}{2}$

A pinon, 8 inches diameter, bears north 10 links distant, marked $\frac{W}{2}$

A granite bowlder, 4 feet in diameter and 3 feet above ground, bears S. 82° E., 223 links distant, marked $\frac{W}{2}$

Thence N. 15° W.

2.00 ascend slope, through small scrubby pinon.
10.00 corner No. 3, a limestone 3″×7″×26″ in mound of stone, marked $\frac{R}{3}$ on SW. slope of a hill, about 150 feet above the ranger cabin.

Chimney of cabin bears S. 45° 30′ W.

No suitable witness objects within 3.00 chains.

Thence S. 58° W.

(There is evidently local attraction at this point, since my backsight reading is S. 14° E. The compass needle therefore reads S. 59° W. on this course.)

Running down slope.

12.60 ravine, course south.

26.80 foot of slope. Leave pinon, enter willows and cottonwood.

28.53 cross north fork of Wildcat Creek, flows S. 18° E.

29.00 enter open yellow pine timber.

35.00 corner No. 4. A stake of pine heartwood in mound of earth, marked $\frac{R}{4}$

A yellow pine, 2 feet in diameter, bears N. 14° E., 18 links distant, marked $\frac{W}{4}$

A fir, 12 inches diameter, standing on right bank of north fork of Wildcat Creek, bears S. 42° 30′ E., 134 links distant, marked $\frac{W}{4}$

(As my backsight reading is now N. 58° E., I conclude that there is no local attraction at this point.)

Thence S. 15° E.

through open pine timber.

2.96 pine tree 2½ feet in diameter.

5.00 leave pine timber.

7.24 cross Wildcat Creek flows S. 23° W.

10.09 corner No. 1, the place of beginning, containing 33.63 acres of land, be the same more or less.

JOHN R. UNDERWOOD,
Ranger Surveyor.

Field notes and plat compared and approved by—

GEORGE A. OVERMAN,
Supervisor.

FOREST HOMESTEAD SURVEYS.

These surveys will be made in the same manner as those for ranger stations, but to avoid some confusion and to distinguish them the following system of marks should be used:

Forest Service *monuments,* which are established for homestead surveys, will be marked F S M H *Witnesses* for these monuments will be marked $\frac{\text{M H}}{\text{W}}$ *Corners* will be marked with H and the number of the corner, thus: $\frac{\text{H}}{2}$ and a *witness* to the same corner will be $\text{H}\,\frac{\text{W}}{2}$ When a monument is also the initial point of the survey, and is therefore also corner number 1 it will bear both marks, thus: $\text{F S}\,\frac{\text{M H}}{1}$

If a F S M is subsequently used as a tie for a forest homestead survey its original marks will not be changed. In like manner a F S M H may be used as a tie for a ranger station or other subsequent survey without changing the original marks. The field notes will, of course, show unmistakably what tie was used.

The type of cover of the land must be clearly shown on the map accompanying the reports. For this purpose Forest Atlas Legend crayons or color tints will be used.

The establishment of corners will not be required where it can be conclusively shown in a written report that listing of the land should be denied.

The surveyor should be thoroughly familiar with the instructions under the act of June 11, 1906. Attention

is also called to the circular of the General Land Office, September 7, 1906, "Regulations Governing Entries within Forest Reserves."

A cooperative agreement between the Departments of the Interior and Agriculture, dated September 19, 1911, to avoid duplication or unnecessary work in surveying forest homestead claims, provides that instead of two surveys, as heretofore required, there shall be but one survey, and that it may be made by a forest officer, designated by and acting under the direction of the surveyor general, "who will exercise supervision in every case as to the manner of the execution of the survey with reference to the running of lines and the establishment of monuments to mark the same."

Such surveys are for the approval of the surveyor general and acceptance by the General Land Office. The instructions of the surveyor general will be followed in these cases, even though they conflict entirely or in part with the methods of the Forest Service.

TRAIL SURVEYS.

In surveying for railways, roads, or trails, the *vertical deflection* of the line is always expressed in *per cent.* Thus, a 5 per cent grade means a rise of 5 feet in 100 feet of horizontal distance. The *horizontal deflection* of the line is always expressed in *degrees.* Thus, a railway may have a 3° curve, which is a horizontal deflection of 3° in 100 feet, from chord to chord, or a road may have a change in direction of 3° at the junction of two courses. *Percentage* of grade and *degrees* of azimuth should never be confounded, as very serious errors will result. The terms are never interchangeable.

The most important thing about a trail is its grade. Any other feature of its construction may be improved from month to month or from year to year, but if the grade is not properly established it must in time be abandoned. Thus, not only may time and money be wasted, but the trail, while in use, would be unsatisfactory. On the other hand, if the grade is properly located, the trail will be useful as soon as it is passable.

The best gradient between any two points is upon a line which would have the same percentage of rise from beginning to end. Often there are "salient points" along the route, above or below which the grade must run, and we must then think of the line as divided into parts, each with its own percentage of rise between these salient points. If an even gradient is also a low gradient, it is unquestionably the proper location for the trail if construction is practicable. The same is true if the gradient is on the most direct and practical route and is below the maximum for trails.

Reverse grades should be avoided if possible. This means that we should never go downhill when the object is to go uphill, as this obviously increases the elevation to be climbed, and therefore increases the grade upon the ascending portions of the trail.

There are three maxima grades for trail construction. These are: 6 per cent, 12 per cent, and 18 cer cent. Being multiples of 6, these are easy to remember, as are also the reasons for having several maxima. A good grade, having a maximum of 6 per cent, may later be developed into a first-class road or turnpike. Such a grade might be called, for convenience, a *turnpike*

grade. The surveyor should try his very best to get the trail upon a turnpike grade, but if this is obviously impracticable, he should keep the grade as low as possible, and not exceed 12 per cent. This is the limit for safe mountain roads such as are used for freighting, and might properly be called a *freight grade.* When trails must be constructed upon grades steeper than this, or to places which roads can not reach for many years, it is simply a case of making the best location the circumstances permit. However, there is still the final limit which should not be exceeded. This is the *trail grade* of 18 per cent, and is as steep as a loaded pack animal can ascend without violent and exhaustive effort. Long steep grades should have breaks at intervals where animals may rest and recover.

In deciding on a route or location, the following points should be considered.

(1) A south exposure has less snow, is dryer, often more open, and has an increased fire hazard.

(2) Slide rock and other unstable material make a temporary or dangerous tread.

(3) Steep side hills, near the angle of repose, are liable to landslides or snowslides.

(4) Bridges and temporary structures should be avoided as far as possible.

(5) The permanence of a trail depends on the material and its drainage.

It will be seen from the above that the location of a trail grade is almost wholly a matter of experience and good judgment.

The aneroid barometer is often used to determine the distance in elevation between the ends of the proposed trail, and the approximate distance may be determined by pacing. This furnishes a preliminary reconnaissance. A "trial" or "random" line may then be run from one end of the proposed line to the other on the approximate average grade, which has been determined by reconnaissance. This may be done by a grademeter, an Abney level, or a Locke level.

The grademeter is used as described on page 29. As the circular pendulum is graduated to tangents it may be used to line in the grade to any desired per cent, either uphill or downhill. It is unnecessary to consider the matter of distance, because grade, as thus measured, is an absolute quantity in itself.

The Abney level is used in a similar manner, but it contains no swinging pendulum, and must be set to the desired grade before the sight is taken to the instrument. Some of the Abney levels are graduated to degrees; others to degrees and slopes, in the proportion of 1:1 and 1:10; others have graduations for per cent. This has led to some confusion, and some bad construction has resulted. Care should be used to apply only the per cent when this instrument is in use on trails.

The Locke level is a simple hand level which does not sight either uphill or downhill; it is used by sending an assistant ahead with a pole, upon which sights are taken through the barrel of the level. Allowance must be made for the height of the surveyor's eye above the ground. Thus, if his eye is 5 feet above the ground he can fix the location of a 5 per cent grade by working

uphill and taking a sight on the ground at a point 100 feet distant, or by sighting downhill at the top of a pole which is 10 feet high and 100 feet distant.

For running different gradients, of course the height of the surveyor's eye remains the same, and the length of the sight is changed according to the grade. Thus, a sight on a 10-foot pole, looking downhill, in a distance of 50 feet, would give a 10 per cent grade; and a sight, uphill, on the ground at a distance of 50 feet, would give a 10 per cent grade, still assuming the height of the surveyor's eye to be 5 feet. In the same manner, if the sights, both uphill and downhill, were 200 feet, the grade would then be $2\frac{1}{2}$ per cent.

The use of these instruments is to some extent a matter of individual preference.

In the large majority of cases the grade should be located by a downhill survey. This is always the case when a pass or saddle is the salient high point. When the grade connects two salient points the location may be run in either direction. The alignment of the trail, or its meanders, may be determined by a compass survey after the trail is constructed. It is a matter of secondary importance and should be given no consideration if it takes any time which might have been spent in getting the best possible grade. The importance of alignment should not be entirely overlooked, however, and where two or more routes would give equally satisfactory grades, then the one should be chosen which will have the most favorable alignment, together with shortness of distance, and which will require the least number of bridges and culverts, and in other respects afford the most favorable conditions for construction.

PLATTING THE SURVEY.

When a plane table is used, the survey and platting progress together, but if other methods are used it is necessary to "plat" the notes. This should be done on the prescribed forms, using one of the standard scales which are described on page 66. Be sure that the plat shows the scale, as well as "what it is, where it is, who made it, and the date." If the plat does not "close," throw the error into the sides or angles which are most liable to be inaccurate on account of difficulties in the field work. If local attraction was encountered at one corner the error is likely to be in that angle. If offsets were made, or very rough or steep country traversed on one side, the mistake is probably in the chaining of that side. An error of one link to the chain is allowable. If a larger error appears in platting, the field work *must* be repeated.

MAP MAKING IN THE FIELD.

After the salient points of the topography have been located by plane table, and the roads, streams, or summits have been traversed by compass surveys, it remains for the surveyor to sketch in the contours. Some of this may be done when the peaks are located and when the distances are chained, and the result is a skeleton map upon which it remains to fill in the balance by the eye. This is a matter of practice. It is an excellent plan to learn to read contour maps, such as are published by the Geological Survey, and the student should provide himself with a topographic sheet of some region with which he is well acquainted and learn to

identify the relief with its contours. When this is mastered a good contour map will be almost as graphic as a miniature model of the country.

In sketching contours it is of great assistance to imagine the sea level raised. Thus, if the 5,000-foot contour is being sketched, we may imagine that the salt waters of the earth are raised 5,000 feet higher than they now are. It is evident that the true contour would follow the shore line which is thus imagined and that bays and harbors, islands, straits, etc., would result. It is evident that contour lines can not cross each other or themselves and that they must connect somewhere, either on the map which is being prepared or in some other region.

The contour map, when thus prepared, is only a base map for other data to be collected for the Forest Service. Some of this data may be collected as the survey proceeds, such as the classification of the land, timber, woodland, barren, etc., or the composition and stand of a forest. When the plane-table map is being made in the field, the paper is necessarily covered with pencil notes and lines which give the names of points, elevations, directions, etc. There is no need to encumber this map with other figures or names which may be confusing or lead to error. A better plan is to cover the map with a piece of tracing cloth, with the dull side up, which may be thumb-tacked along one side only, that it may hang back out of the way when work is being done on the base map. On this the burns, windfalls, barren areas, or stand may be sketched either in black or with colored crayons without smearing the base

map or obliterating any of its topographic data. Some salient points on the base map should be copied on the tracing cloth so that the two may be registered at any time, for the paper may shrink or the cloth may stretch.

THE FOREST ATLAS.

The *Forest Atlas* at Washington is the central depository for maps, diagrams, statistics, and history of the National Forests and forestry in general throughout the world. Its most important division is that of maps, and the most important maps are those of the National Forests.

The Forest Atlas now comprises 190 volumes, containing *sheets* exactly 18 by 21 inches. They are bound in loose-leaf holders in two ways. *Standard binders* have the binding margin on the 21-inch side, while *township binders* have the binding margin on the 18-inch side. No map is made on a sheet less than 18 by 21 inches, and larger maps are made on two or more sheets which are always numbered from west to east beginning at the northwest corner. Borders are omitted. The title consists only of the name of the forest or the number of the township. The top of the map is always north. A binding edge of at least $1\frac{1}{2}$ inches is always left blank on the west or left-hand side of each sheet.

The *standard scale* of the Forest Atlas is 1 inch to 1 mile, and the National Forests have been practically covered by atlas sheets according to this standard. Whenever, in special cases, a larger or smaller scale is necessary for the preparation of any map in the Forest Service, it must sustain the simple relation of $\times$ 2

or ÷ 2. Thus the scale may be 2 inches, 4 inches, or 8 inches to 1 mile; or $\frac{1}{2}$ inch, $\frac{1}{4}$ inch, or $\frac{1}{8}$ inch to 1 mile. Under no circumstances will sheets be prepared for the Forest Atlas on the ratio of 3, 5, 7, etc. The scale of *township plats* is 2 inches to 1 mile, because that scale was adopted by the General Land Office, from which the plats were procured.

The Atlas sheets which cover a National Forest are called a *folio* and are assembled, with a *legend page*, in a paper *cover*, on which is printed an *index diagram* showing the number of the sheets.

In the office of each district forester is a *District Atlas* consisting of 20 or more volumes, containing duplicate sheets of the Forest Atlas covering the area of the district. Whenever Forest Atlas folios have been duplicated by photolithography or otherwise for a National Forest, the officers have been supplied with copies, but under no circumstances are copies of any atlas folio to be sold or given away. They are strictly for the use of forest officers in the administration of the National Forests. Copies for distribution are not published.

Forest Supervisors are supplied by the property clerk with binders for Forest Atlas folios, having the binding margin on the 21-inch side, and also with binders for Land Office township plats, having the binding margin on the 18-inch side.

The folios are the "mother maps" which furnish the bases from which further map making will proceed in the Forest Service. They correspond to the mother maps of other countries in this respect—that they are compiled from official data upon a standard scale, 1

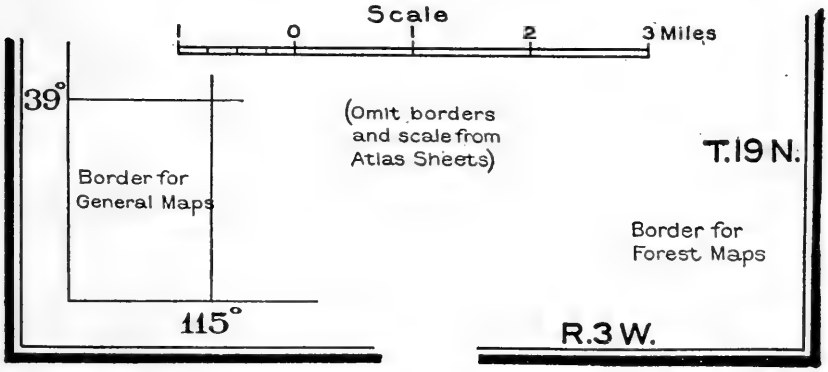
inch to 1 mile,[1] and upon a uniform legend. They are not always sufficiently accurate for forest work, and the sheets must, therefore, be corrected whenever new data have been obtained in the field. The manner of correcting sheets is shown on the "dummy Atlas sheet," which has been issued to forest officers. The method is that used by printers in correcting proof. Bold lines should be drawn to the margin of the sheet and explanatory notes written clearly. Do not make neat corrections without the marginal note, or it will not be apparent that the sheet has been corrected. Do not write letters or memoranda telling how a sheet should be corrected. Do it yourself. Do not be afraid to mark up any sheet because it is beautifully engraved or colored. Your corrections will make it more valuable.

New data obtained by reconnaissance is usually mapped on a scale of 2 inches or 4 inches to 1 mile. Such data should not be redrawn to the standard Atlas scale in the field. The reconnaissance tracings should be sent to Washington with a requisition, Form 988, for photoreduction. For this and other reasons reconnaissance tracings and other base maps should be drawn with black ink only, and should show only the drainage, contour, culture, and land lines. Other data, such as classification, forest or grazing types, or administration districts, can be shown by appropriate colors upon two or more prints. By this method the tracing remains a record which is subject to very little change,

[1] The mother maps of Great Britain and India are on the same scale as the Forest Atlas standard. Those of France, Spain, Italy, Switzerland, and Sweden are nearly the same, 1¼ inches to the mile. Those of Bosnia, Herzegovina, Norway, Bulgaria, Hungary, Russia, and Portugal are on smaller scales; those of Germany, Belgium, Denmark, and the Netherlands are on larger scales.

CONVENTIONAL SIGNS

- Wagon road
- Secondary road
- Trail
- Railroad
- Telegraph line
- Telephone line
- Power line
- Pipe line
- Aqueduct
- Fence
- Ditch
- Flume
- Bridge
- Corral
- Supervisor's headquarters
- Ranger's h'dq'r's, no house
- Ranger's h'dq'r's, with house
- House
- Railroad station
- Stage station
- Power station
- Hotel
- Store
- School
- Church
- Cemetery
- TEL. Telegraph office
- TLP. Telephone office
- Cabin
- Logging camp
- Sawmill, portable
- Sawmill, stationary
- Grist mill
- Grist and sawmill
- Apiary
- Windmill
- Well
- Quarry or gravel pit
- Mine location, unpatented
- Mine shaft
- Triangulation station
- B.M. /232 Bench mark



LETTERING.

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 123456789

(topography)

UPPER CASE USED FOR TITLES MOUNTAIN RANGES, STATE NAMES, TOWNSHIP AND RANGE NUMBERS, GRANTS, AND RESERVATIONS, ALPHA-NUMERIC SYMBOLS.

Upper and Lower Case for Peaks, Valleys, Islands, Capes, etc., Meridians and Parallels, Legends and Scales.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z 1 2 3 4 5 6 7 8 9

(culture)

UPPER CASE FOR RAILROADS, ROADS, TELEPHONE LINES, AND OTHER MEANS OF COMMUNICATION.

Upper and Lower Case for Other Culture.

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 123456789

(settlement)

UPPER CASE FOR CITIES, STATE, AND COUNTY BOUNDARIES.

Upper and Lower Case for Towns, Villages, Post Offices.

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 1234567 89

(water)

UPPER CASE FOR OCEANS, LARGE RIVERS, LAKES, ETC.

Upper and Lower Case for Small Rivers, Creeks, Springs, Marshes, Glaciers, Canals, Ditches, etc.

and is not obscured by data which is of special rather than general value. The first reconnaissance of any area should include the drainage and contour, otherwise it will not be possible to "register" a second or supplemental reconnaissance with it.

General maps, showing an entire Forest or region are compiled at Washington from data on the corrected Atlas sheets, and are issued for the use of forest officers. The usual process is photolithography. Every request for the issuance of a map should be submitted to the Forester with a recommendation regarding the data to be shown or omitted, scale, kind of paper, and number of copies required. Any project for the issuance of a "three-color map" with blue drainage, brown contours, and black culture should be taken up by correspondence with the Forester before the final tracings are prepared, in order that the manuscript may be in good shape for the engraver.

The Forest Atlas legend page, which has been supplied to all forest officers, shows the standard scheme of colors and symbols which are used in the preparation of all atlas sheets.

It should be borne in mind that National Forests are established in widely different regions; as far north as Alaska and as far south as Florida and Porto Rico. On no two forests will the data suggested on the legend page be of equal importance, and it may be necessary or convenient to adopt additional symbols or colors to show unusual conditions. This is quite permissible providing the marginal notes are made explanatory or if the sheet is subject to only one interpretation by forest officers who will have to use it.

An atlas sheet or any other map should show plainly the information it is intended to convey, and artistic flourishes, fancy type, or border designs are useless. It should show what it is, where it is, the scale, who made it, and the date. It should show also by whom the field examination or survey was made and the date of the same. If it is from an original survey the magnetic variation should be given. On the borders of the map, if the area shown covers more than one township, the township and range numbers should be given, and also, if possible, one or more meridians and parallels. If a degree meridian does not fall in the map, then some intermediate may be given, such as 10′ or 20′. Table 7 will be found convenient.

TABLE 7.—*Lengths of degrees on meridians and parallels at different latitudes on the earth.*

At latitude—	Length of 1° on meridians.	Length of 1° on parallels.	Convergence in one township or in two meridians 6 miles long and 6 miles apart.
	Miles.	*Miles.*	*Links.*
26°	68.84	62.21	35.4
27	68.85	61.68	37.0
28	68.86	61.12	38.6
29	68.87	60.55	40.2
30	68.88	59.96	41.9
31	68.89	59.34	43.6
32	68.90	58.72	45.4
33	68.91	58.07	47.2
34	68.92	57.41	49.1
35	68.93	56.72	50.9
36	68.95	56.03	52.7
37	68.96	55.31	54.7
38	68.97	54.58	56.8
39	68.98	53.83	58.8
40	68.99	53.06	60.9
41	69.01	52.28	63.1
42	69.02	51.48	65.4
43	69.03	50.67	67.7
44	69.04	49.84	70.1
45	69.05	49.00	72.6
46	69.07	48.14	75.2
47	69.08	47.26	77.8
48	69.09	46.37	80.6
49	69.10	45.47	83.5

The atlas sheets show the alienation of lands within National Forests, but it must be understood that data of this kind can not be accepted as final authority, but may be regarded as presumptive evidence. It has required three years to collect the alienation data for the National Forests, and since their status changes from day to day, while the compilation and publication of atlas sheets requires several months, it is evident that a folio can not be issued to forest officers which will be up to date in this respect. It is only by keeping new data posted on the sheets that the office record can be kept up to date.

Maps are never perfect, nor do they approach perfection unless repeatedly altered and corrected in accordance with dicoveries or changed conditions. Although the Forest Atlas sheets are compiled in every case from the best data available, they are often far below the standard which should obtain in forest maps. It will not be regarded as a reflection upon the compiler of a sheet if a large number of corrections are found necessary, and field officers should never hesitate, for this reason, about sending in data.

The coloring tints which are used in the classification scheme may be prepared as follows from standard inks that will be furnished by the property clerk at Ogden, upon requisition:

Forest Atlas—Color prescriptions.

	Parts.
Timberland:	
Less than 2,000 board feet per acre—	
Green ink	2
Yellow ink	1
Water	3

	Parts.
Timberland—Continued.	
2,000 to 5,000 board feet per acre—	
Green ink	1
Water	3
5,000 to 10,000 board feet per acre—green ink.	
10,000 to 25,000 board feet per acre—	
Brown ink	3
Green ink	3
Yellow ink	2
25,000 to 50,000 board feet per acre—	
Brown ink	4
Green ink	2
Yellow ink	1
Water	7
Woodland, cordwood, etc.:	
Green ink	1
Yellow ink	2
Water	8
Chaparral or brush:	
Brown ink	1
Water	5
Sagebrush:	
Brown ink	3
Yellow ink	2
Orange ink	2
Water	10
Grassland, parks, etc.:	
Yellow ink	1
Water	1
Barren land:	
Black ink	1
Water	20
Burn, forest cover established:	
Green ink	1
Yellow ink	2
Water	8

	Parts.
Old cuttings:	
Brick-red ink	1
Water	3
Cultivated—red ink.	
Mineral lands—orange ink.	
Open for cattle and horses only:	
Brick-red ink	1
Water	3
Open for sheep and goats only:	
Yellow ink	1
Water	1
Closed for all stock—orange ink.	
Driveways for stock:	
Black ink	1
Water	20

When timber or woodland has been partly burned, the lining for burns may be used on top of the green. When partly cut over, or culled, the proper signs may be used in the same manner.

FOREST ATLAS CRAYONS.

In order to secure uniformity in coloring field maps, boxes containing 12 crayons are furnished, with a descriptive label, for use with the Forest Atlas legend. They are as follows:

COLORED CRAYONS.

General classification.

69. Less than 2,000 B. F.
29. 2,000 to 5,000 B. F. (light).
29. 5,000 to 10,000 B. F. (heavy).
15. 10,000 to 25,000 B. F. (light).
15. 25,000 to 50,000 B. F. (heavy).
63. Woodland, cordwood, poles, etc.
87. Chaparral or brush.
37. Sagebrush.
2. Grassland, parks.
6609. Barren, above timber line, etc.
63. Burn, forest cover established.
72. Old cuttings.
46. Cultivated.
62. Mineral.
58. Water.

Grazing map legend.

58. Administrative divisions.	2. Open for sheep and goats only.
72. Open for cattle and horses only.	62. Closed for all stock.
	87. Driveways for stock.

The property clerk has installed a machine for printing the Forest Atlas legend upon each colored crayon, and it is expected that this improved method of marking will lead to greater accuracy in the use of colors on maps. There have always been some uncertainties, due to the fact that many men are not good judges of color, and also because the makers of colored crayons change the formulæ for mixing colors or use different grades of pigment. It has also been found in the case of some colors that they change materially with age. Under this new method of marking it will be possible for the property clerk to obtain in each case the best grade of a standard color, and, disregarding the manufacturer's number, print the atlas legend upon the pencil. Thus, the bright yellow crayon will be marked "Grassland, parks, etc.," and "Open for sheep and goats only."

On important work a legend showing the colors and symbols used and their significance should accompany each map or folio.

MOUNTING MAPS ON MUSLIN.

Slightly dampen the muslin and stretch it over a table top or other flat surface. Fasten with tacks not more than 4 inches apart. Wet the map thoroughly by dipping it in water or with a sponge. Remove surplus

water with large blotters. Lay the map face down upon the muslin, and with a wide flat brush (rubber bound) apply paste quickly but evenly over the back of the map. Turn over the map and press it smoothly upon the muslin, using a blotter and roller. Leave it to dry overnight. The hands should be wet when handling a wet map and the surface of the map should be rubbed as little as possible. It is better for two persons to work together, holding all four corners of the map and allowing it to fall upon the muslin from the center toward the corners, thus avoiding air bubbles. If any paste gets upon the face of the map it should be immediately removed with a wet sponge.

Three or four layers of maps may be mounted on the same board, provided a dry piece of muslin (same size as map) be placed between the layers.

In some instances, for convenience in folding to pocket or other small size, the map should be cut into sections, all of the same size and shape, and mounted with a slight break between each section, where the fold will come. In this case, each small sheet must be placed separately upon the big sheet of muslin, which has been previously dampened slightly.

One gallon of paste may be made as follows: Dissolve $1\frac{1}{2}$ pounds of lump starch in 1 gallon of water. Then stir constantly while pouring boiling water over it until the mixture becomes thick. Set aside, and when almost cold squeeze through a piece of cheesecloth in order to remove the lumps.

METHOD OF USING THE FOREST SERVICE STANDARD PLANIMETER.

Planimeters are issued to some forest officers and are used to determine areas platted on maps. They are constructed to register areas in square inches and deci-

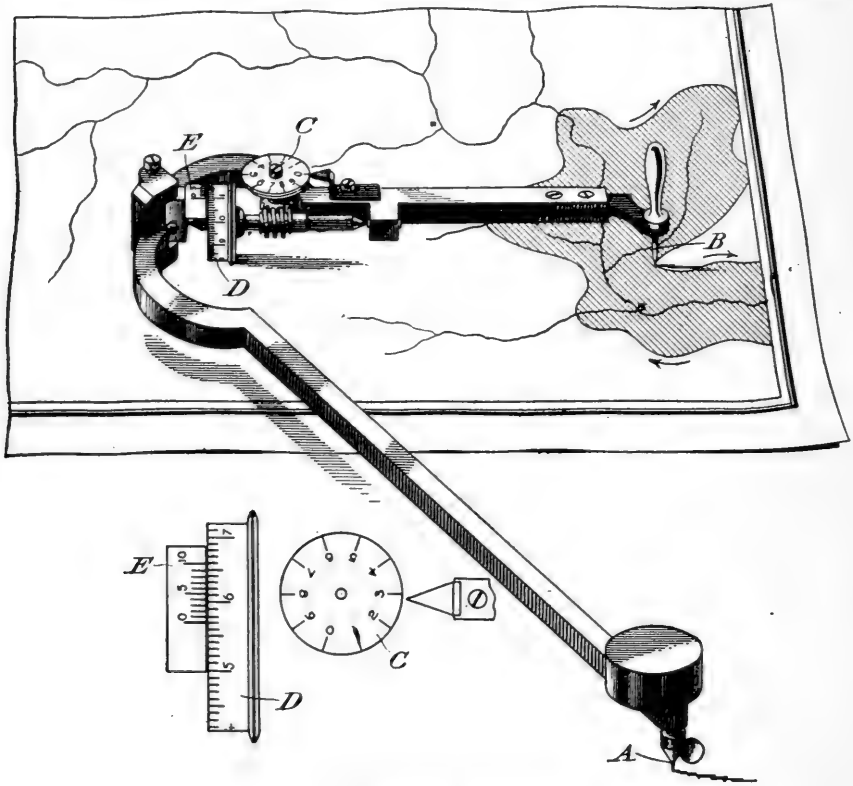


FIG. 12.—Standard planimeter.

mals of 1 square inch and are used in the following manner:

(1) Place the weighted stationary pin, *A*, figure 12, *outside* of the area to be determined, below and to the left, in a position which will permit the "tracing pin,"

B, to follow the entire outline freely. If the area to be determined is too large to permit placing the stationary pin outside, and thus determining the area as a whole, the area may be divided and its parts determined separately.

(2) Place the tracing pin at any starting point on the outline of the area and press it in to make a distinct mark on the surface. Set all the scales at zero with the hand. Then draw the tracing pin around the outline of the area, following it as exactly as possible, until the circuit is completed and the tracing pin rests at the starting point. The circuit must be made in the same direction that the hands of a watch move.

(3) Four figures, representing tens, units, tenths, and hundredths, may be read after the circuit is completed, and the reading may be from 00.01 to 99.99. Figure 12 shows a sample reading of 25.71 square inches because the dial *C* registers 10 square inches for each numbered division. The roller *D* registers 1 square inch for each numbered division. The vernier *E* registers 0.01 square inch to be read against *D*.

It will be noted that the pointer at dial *C* points between 2 and 3. The area in square inches is, therefore, between 20 and 30. The zero on the vernier *E* serves as a pointer for the roller *D*. This reads between 5 and 6. Therefore the integral area is 25. Counting the divisions between the figures 5 and 6, it is seen that the zero on the vernier barely passes the seventh mark. Therefore the first decimal is 0.7. By looking along the vernier *E* it will be seen that one of the graduations falls exactly opposite one of those on

roller *D*. This will happen in every case and the number of this mark on the vernier will determine the second decimal. In the diagram the first mark to the right of the zero falls opposite a mark on roller *D* and therefore the reading is 0.01. Thus the total reading is 25.71 square inches. Use a magnifying glass if necessary.

(4) The area in acres is found by multiplying the figure given by the planimeter by coefficient determined by the scale on which the map is drawn. If the scale be 1 inch to the mile, 1 square inch will represent 640 acres. If it be one-half inch to the mile, 1 square inch will represent 4 square miles and the acreage will be determined by multiplying the instrument reading by 640×4, or by 2,560. If the scale be 2 inches to the mile, 1 square inch will represent 160 acres; and so on for any desired scale.

(5) Blueprints and other photographic papers are never exactly to scale, but a conventional mile on the print can be planimetered, and the reading thus obtained will be known to represent 640 acres.

(6) On important work the area should be planimetered several times and the results averaged.

(7) For practice, a regular figure, such as a square containing a known number of square inches, should be planimetered until the reading on the instrument agrees substantially with the known area.

(8) Only an expert should attempt to adjust a planimeter. If the instrument does not work properly it should be returned to the property clerk for repairs.

LAND OFFICE SURVEYS.

The rectangular surveys of the United States Land Office control throughout the West and divide the land

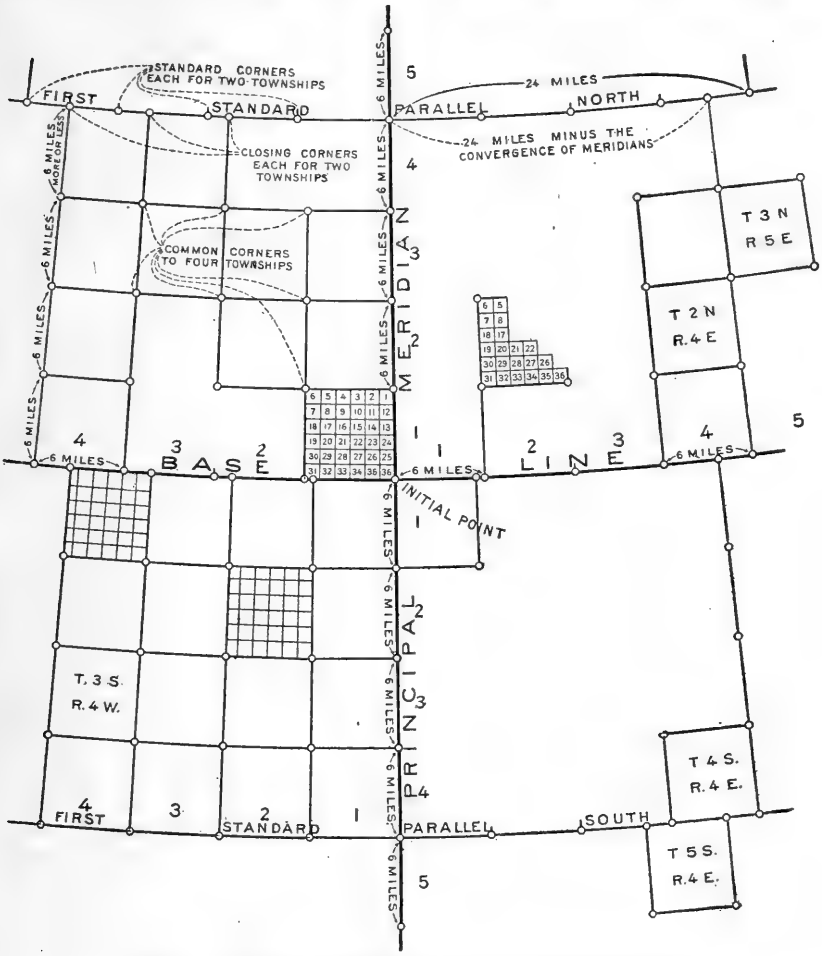


FIG. 13.—Rectangular system of Land Office surveys.

surfaces into squares, which may be divided and subdivided, quartered, quarter-quartered, etc. The unit

of the system is the township, which is, conventionally, 6 miles square and contains 36 sections of 640 acres each, or 23,040 acres.

Inasmuch as meridian lines converge toward the North Pole, it is evident that townships will have a trapezoidal form and that they will materially decrease in area toward the north unless correction lines are introduced. The system is as follows (see fig. 13, p. 81):

Beginning at the initial points, a base line is run due east and west with standard parallels 24 miles distant. From these parallels guide meridians, 24 miles distant, are run due north and "close" on the standard parallels. This divides the region into tracts 24 miles square, except for the convergence mentioned. Then township lines are run, making tracts which are 6 miles square. These are afterwards "subdivided" into sections. The conventional section is legally subdivided into quarters and quarter-quarters, and by common usage into smaller subdivisions, but unless otherwise specified these are all proportionate areas to the quarter section. A conventional section is cut into quarters by straight lines which connect the quarter corners on its boundaries.

Whenever, as in the case of timber sales, it becomes necessary to survey and mark a line which bounds some alienation, it is important that the line should be either legally correct or should be agreed to in writing by the private owner for the purpose of the sale, and in case of a disagreement no timber should be marked for cutting in the disputed strip until the merits of the case have been submitted to the Forester and his instructions received.

There are many exceptions to the simple rectangular scheme as outlined above, and many different anomalous townships and sections result from methods which have to be employed in special cases.

RESURVEYS.

When a survey is to be made in a township which has been subdivided, or when the lines of old survey boundaries are to be retraced, the prime object is to *follow* all of the legal lines and to check up on all of the legal corners. For this purpose the surveyor should know:

(1) The date when the original survey was made.

(2) The variation used.

(3) The change in variation, increase or decrease, since the original survey was made.

In any Western State this information may be obtained from the surveyor general, and usually from the county surveyor of the county in which the survey is to be made. In any event the new variation, as determined by the resurvey, should be entered in the field notes for future reference.

CANCELLATION OF MISLEADING MARKS ON FORMER FOREST BOUNDARY POSTS.

Forest officers are cautioned that the agreement between the General Land Office and the Forest Service in regard to the cancellation of certain misleading markings on National Forest boundary posts does not extend to any of the existing regulations against changing the markings on any posts other than as herein specified

Owing to changes in some National Forests many of the metal posts used to mark the boundaries, as surveyed by the Geological Survey and approved by the General Land Office, have become misleading. As these posts usually mark section corners, and also furnish valuable points for reference, they must not be removed, but their misleading marks may be canceled. This will be done by cutting, with a sharp cold chisel, a line through any misleading word or words, the intention being to cancel them without rendering them illegible.

On no account shall any portion of the markings which are still true, or partly true, be thus canceled. For example, in the following cases, the words which, in a National Forest, may be canceled are shown.

~~AQUARIUS~~ FOREST RESERVE ~~BOUNDARY~~ POST NO. 27.

BLACK HILLS ~~BOUNDARY~~ POST NO. 18.

UNITED STATES FOREST RESERVE ~~SAN JACINTO BOUNDARY~~ POST NO. 43.

Outside of a National Forest the words which, for example, may be canceled are shown thus:

UNITED STATES ~~FOREST RESERVE MADISON BOUNDARY~~ POST NO. 37.

In every case when any mark on a post is canceled the same cancellation must be made on the bearing trees if their marks are misleading, by cutting a groove across the word.

A report must be made to the Forester giving the location and number of each post canceled and stating which of the markings thereon have been canceled.

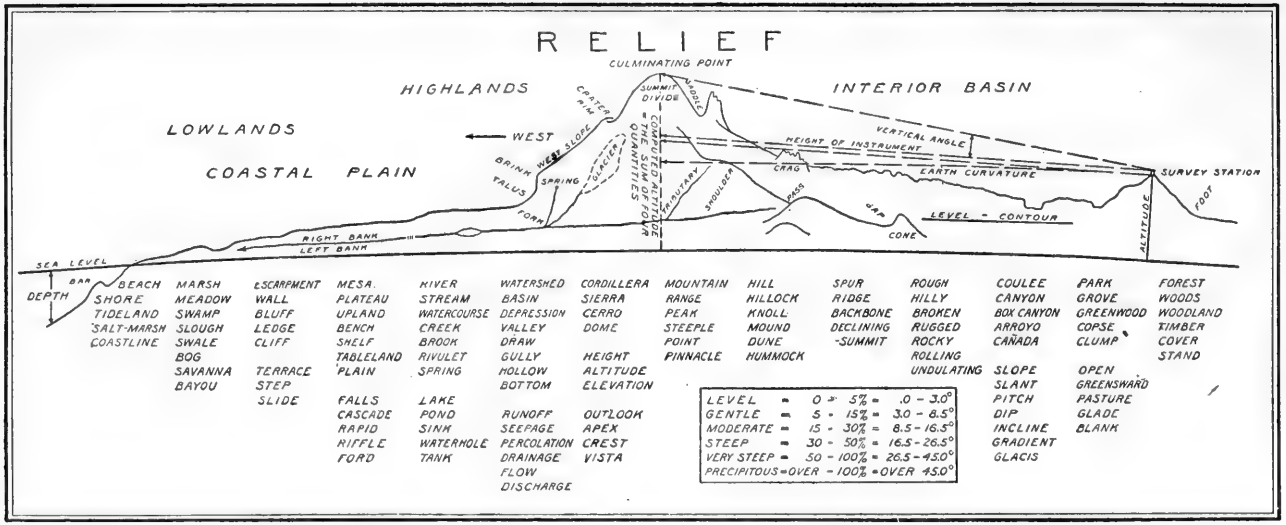


FIG. 14.—Names of physiographic features.

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