USE OF MAPS AND COMPASSES

MARCH 1959

INTRODUCTION

INSTRUCTIONS FOR USE

This manual can be used as a textbook directly by students, but better results will be obtained if an instructor uses the manual as a reference, adapting the material contained herein to the specific need of the students and aiming it at their particular learning level. The material is organized in a manner intended to make it easiest to learn. Under certain conditions, if the students have no knowledge of map reading, it might be desirable to present the section on conventional signs first. All other portions of the manual are dependent on preceding sections, so should be revised if the order of instruction is changed significantly.

Exercises are included for every mechanical operation discussed. They can serve as a guide to the instructor in preparing exercises based on maps of the local area. Exercises should be repeated until the operation concerned is thoroughly mastered and can be carried out smoothly and quickly. The more complicated procedures are broken down into consecutive steps and usually it is not necessary to understand theory in order to solve the problems successfully. Solutions to all problems and exercises are given in Appendix B.

The amount of this subject matter presented to each student is dependent on his specific requirement and should be tailored to his need. This text is basic but is suitable for a review by more advanced students. It has been found through experience that most persons requiring a knowledge of map reading must review the subject at frequent intervals unless they are constantly applying this knowledge. Even after mastering a complete course on map reading, military officers and others often need to review the subject as frequently as once a year to maintain adequate competence.

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LIST OF EXERCISES

I. LOCATION OF POINTS

A. MILITARY GRIDS

1. Description and Purpose. A military grid is a rectangular system of coordinates composed of two sets of parallel lines drawn at equal distances and at right angles (90 degrees) to each other upon a plane, or two-dimensional, map surface. This network of straight lines forms perfect squares covering the surface of all adjacent map sheets in a given area. The military grid system is used in locating points on the map, in measuring distances, and in determining directions. When it is impossible or undesirable to measure distances or directions directly on the ground it can be done rapidly on the map with the aid of the grid. On maps at scales of 1:253,440 to 1:100,000 the grid lines usually are spaced at intervals representing 10,000 meters; maps at scales larger than 1:100,000 usually have grid lines at 1,000-meter intervals. All grid lines are numbered consecutively in multiples of 10,000 (or 1,000) meters, increasing from left to right and from bottom to top of the map.

2. Use. If a given point on the map falls at the intersection of a north-south and an east-west grid line, its exact location can be described by giving the numbers of these lines. The number of the north-south line is always given first, followed by the number of the east-west line.

In Figure 1. notice that the grid lines form perfect squares and may not be parallel to the borders of the map. The two sets of lines are numbered increasing to the right and upward. The numbers appearing nearest the lower left corner of the map are written out in full in two sizes of numbers. Only the large digits of the numbers for the other grid lines are printed. In reading grid coordinates only the large numbers are used, as in Example A. Starting at the lower left corner of the map, read to the right to 23 then read up to 99. In short, READ-RIGHT-UP.

If a point falls between grid lines its exact location can be determined by interpolating its distance between the lines. In example B, point B falls between the lines numbered 20 and 21 and between 00 and 01. Read right to line 20 and estimate or measure to the nearest tenth B's distance beyond line 20--in this case, 5 tenths--and write it as 205. Next read up to line 00 and determine the tenths beyond--in this case, 7 tenths--and write it as 007. The complete coordinates for point B, to the nearest 100 meters, are 205007. Notice that four digits indicate a location within 1,000 meters and six digits describe a location to 100 meters. By further interpolation of two more digits for the coordinates, the location can be stated within 10 meters.

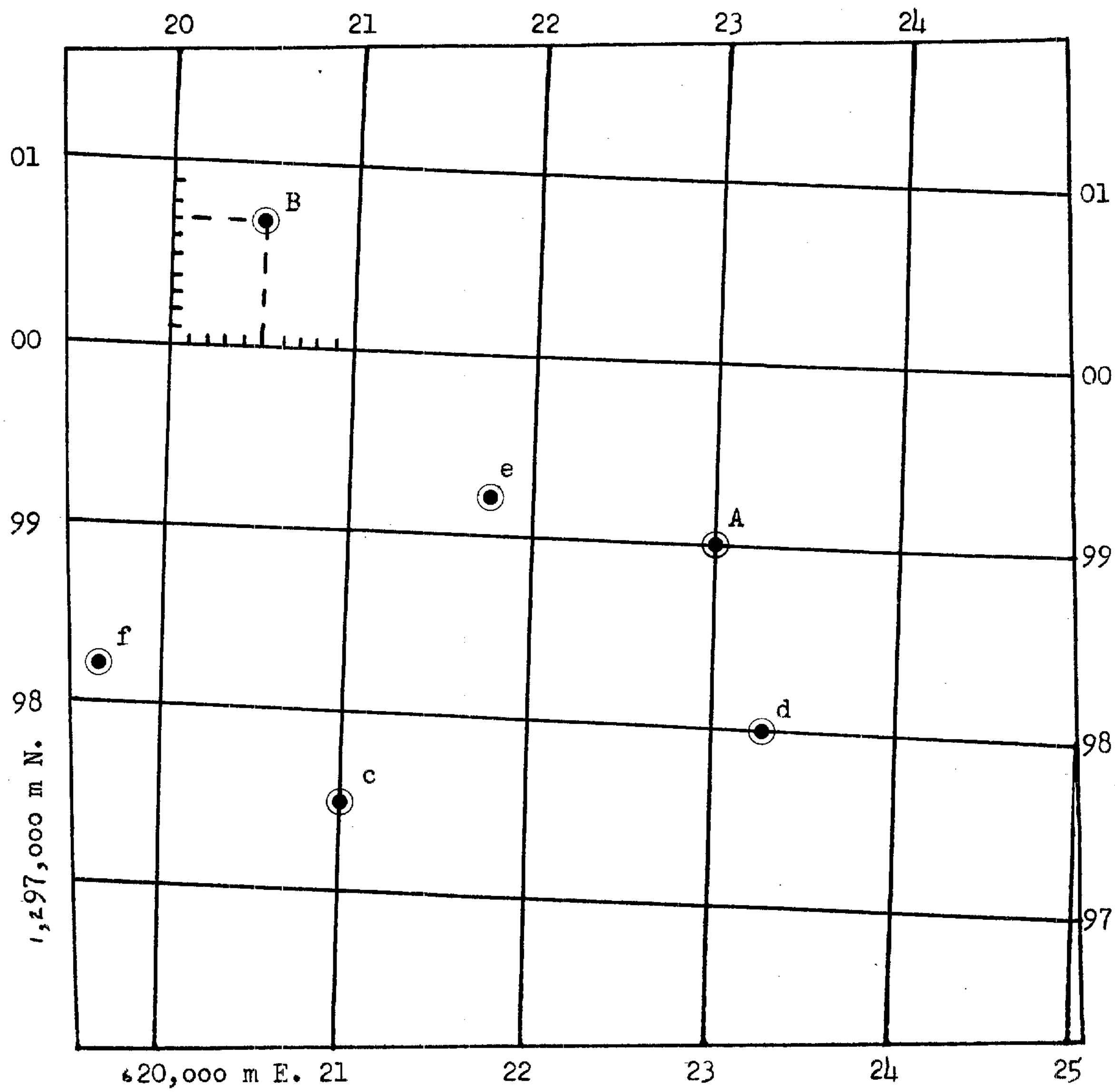

Figure 1. Military grid coordinates.

Example A. Grid coordinates of point A is 2399.

Example B. Grid coordinates of point B to the nearest 100 meters is 205007.

On a series of maps covering a large area the numbering sequence of grid coordinates is repeated every 100,000 meters. This makes it necessary to identify the map on which the coordinates are to be read (see section II F), or to give further grid identification which is printed in a grid reference box in the margin (see section II B) or in the body of the map. This reference usually is in the form of two capital letters which are written preceding the coordinates. Example: BG 250368. The two letters identify the specific 100,000-meter grid square in which the map falls. An additional identification sometimes found on the map indicates the zone, belt, or grid. This is not necessary except when reporting over a great distance, or if the recipient of the report does not know from what area the report originates.

EXERCISE I
Grid Coordinates

(Refer to Figure 1.)

1. Determine the grid coordinates within 100 meters for points:

   c.
   d.
   e.
   f.

   (Note that point f does not fall within a full grid square. The bordering grid lines should be extended to complete the square so its correct distance between lines 19 and 20 can be measured.)

2. Locate as accurately as possible on Figure 1. the following grid coordinates:

   g. 2201
   h. 240973
   i. 205997
   j. 247013

3. Kinds of Military Grids. This discussion has referred only to grid intervals expressed in meters. On maps produced in the past, some of which are still in use, other units of measurement can be found. Examples include British yards, Indian yards, American yards on old polyconic grids, and Russian versts. In most instances these older maps are being replaced with maps containing grids expressed in meters. A few countries may still be publishing maps with other than meter grid intervals.

British and American mapping agencies are among the most productive in the world; together they produce maps of most of the populated areas. Both countries now use the Universal Transverse Mercator (UTM) grid for all areas between 80° south and 80° north latitude. Polar areas are covered by companion Universal Polar Stereographic (UPS) grids. Both grid systems express coordinates in meters. During the transition to these new systems many maps contain both the UTM and older grids.

A number of different grid systems have been used in the past and several of them are still found on current maps. The most common grid, other than the UTM, is the British grid system. This system employs various disconnected zones, belts, and grids throughout large areas of the world. Except for long-distance reporting where it is necessary to identify the zone, belt, or grid, British grids are similar to the UTM grid. Another grid system that was formerly widely used was the World Polyconic grid adopted by the United States during World War II. This grid has been replaced by the UTM grid but may still be found on old map copies. It is used in the same way as the UTM grid. Various countries have used local grids which do not extend beyond a single map series and these may still be in use on some maps. Military grid coordinates are read to the right and up with only a few exceptions, notably a Czechoslovak grid, which reads coordinates to the left and down. The Russian grid zone system is slightly different from the UTM grid but poses no special problems in its use. If reading coordinates from any grid ever causes a particular problem, identifying the specific map (as described in section II F) will enable the recipient of the report to identify the grid and the location in question.

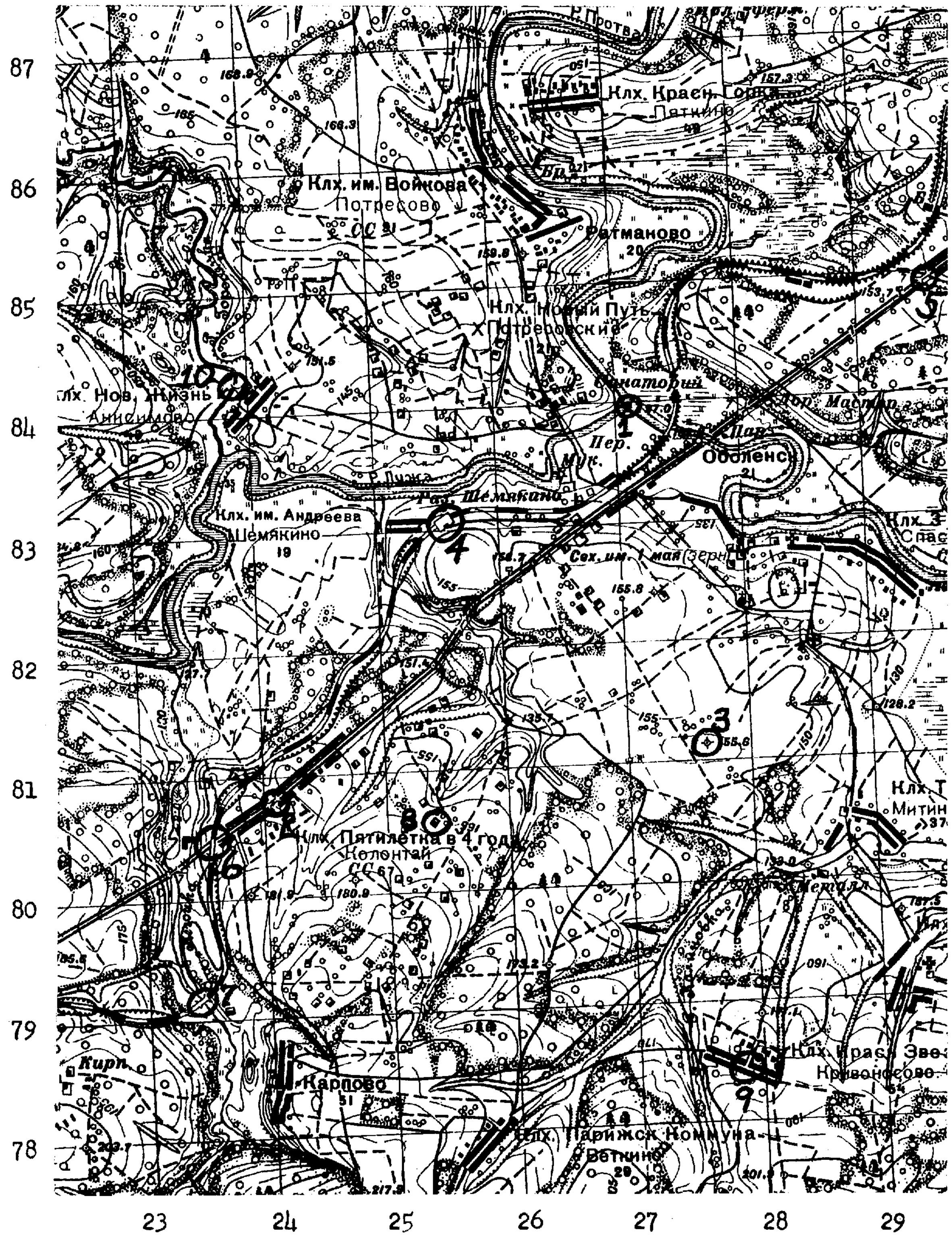

Figure 2. Section from Russian map, 1:50,000.

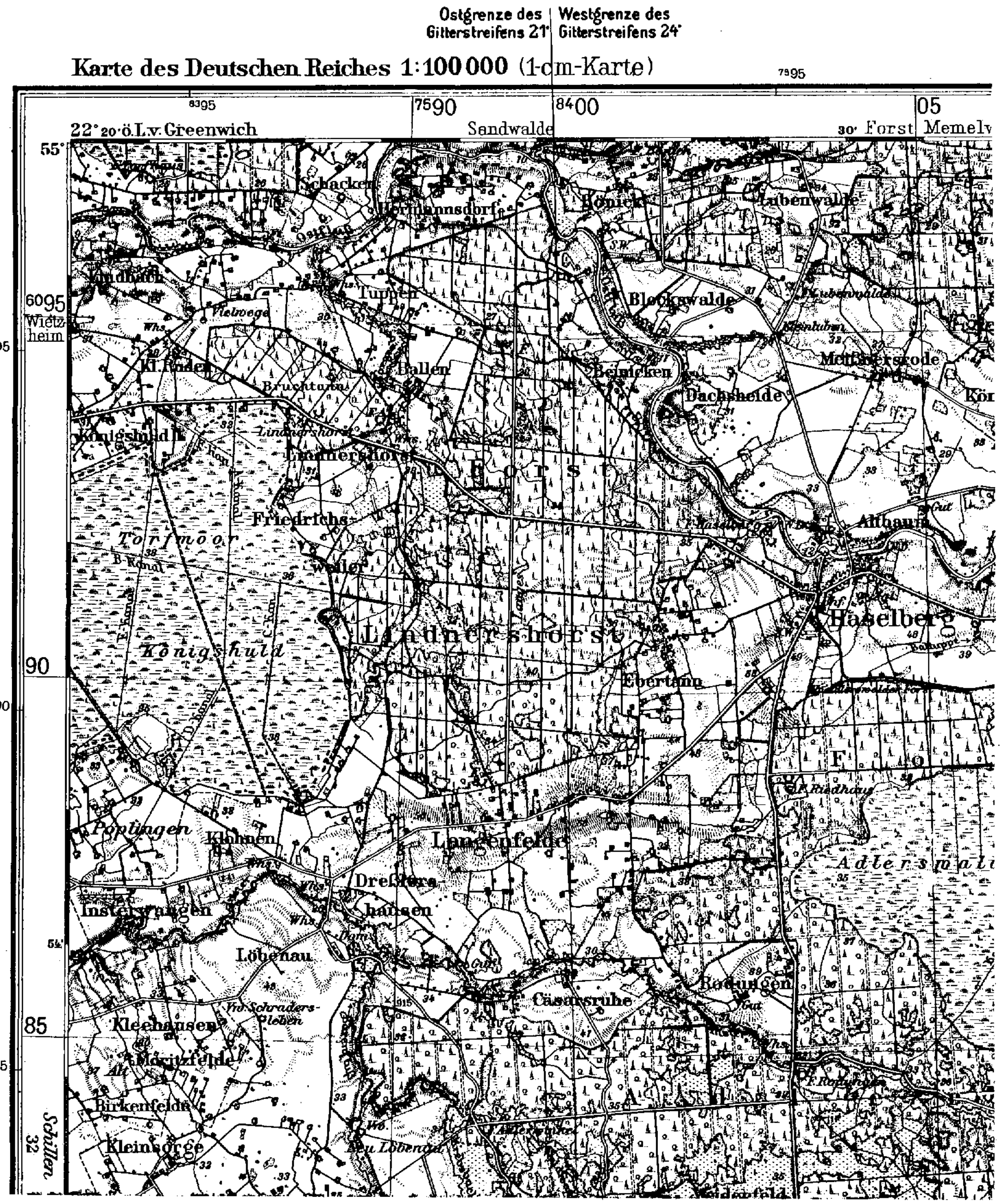

Figure 4. Section of map from Reichkarte series, 1:100,000. Notice the boundary between grid zones, the numbering system, and the tick marks used to extend the grids of the two zones.

EXERCISE II
Reading Military Grid Coordinates

Determine the military grid coordinates within 100 meters for the ten features circled and numbered on Figure 2.

1. ________

2. ________

3. ________

4. ________

5. ________

6. ________

7. ________

8. ________

9. ________

10. ________

B. GEOGRAPHIC COORDINATES

1. Description and Use. A map is a representation of a portion of the earth's surface. To determine the exact portion of the earth represented and to locate points on the map accurately, a frame of reference is needed. A convenient system is a network composed of intersecting horizontal and vertical lines. Numbers assigned to these lines can be stated for any point at which they intersect, and since the network covers the entire earth, these numbers are called geographic coordinates. The horizontal and vertical lines of this network are parallels and meridians.

The horizontal lines are all parallel to each other on the earth, hence the name parallel. The parallel which circles the earth halfway between the north and south poles is the equator. Latitude is distance measured north or south from the equator. Parallels of latitude are drawn at uniform distances on the globe and map. The latitude, or distance north or south of the equator, of any point on the earth can be indicated by describing the parallel which passes through the point. Since it takes the intersection of two lines to locate a point, it is necessary to give also the description of another line which is perpendicular to the parallel and passes through the point. This line extends between the north and south poles and is called a meridian. Meridians extend only halfway around the earth and the distance between them at the equator is approximately equal to the distance between the parallels. Since the meridians converge toward the poles, they are not the same distance apart throughout their lengths.

Both parallels and meridians are designated by numbers. The equator is numbered zero. Since there are 360 degrees in a circle, the distance measured along the surface of the earth from the equator to either of the poles is one-fourth of a circle, or 90 degrees. Therefore, parallels are numbered from zero to 90 degrees, north or south of the equator. For example, the parallel halfway between the equator and the north pole is labeled 45° N. (See Figure 5.)

Unlike the parallel called the equator, there is no logical meridian to label zero and from which to number the other meridians in east and west directions. Therefore, the zero meridian, or prime meridian, was selected arbitrarily, and for the sake of convenience the meridian passing through the observatory at Greenwich, England, is most commonly used as the prime meridian. Some countries use different prime meridians, however, so it is necessary to know definitely which prime meridian is used. Longitude is measured both east and west from the zero meridian to the 180-degree meridian halfway around the earth. By indicating the latitude north or south of the equator and the longitude east or west of the prime meridian, one can locate any point on the earth's surface accurately and definitely.

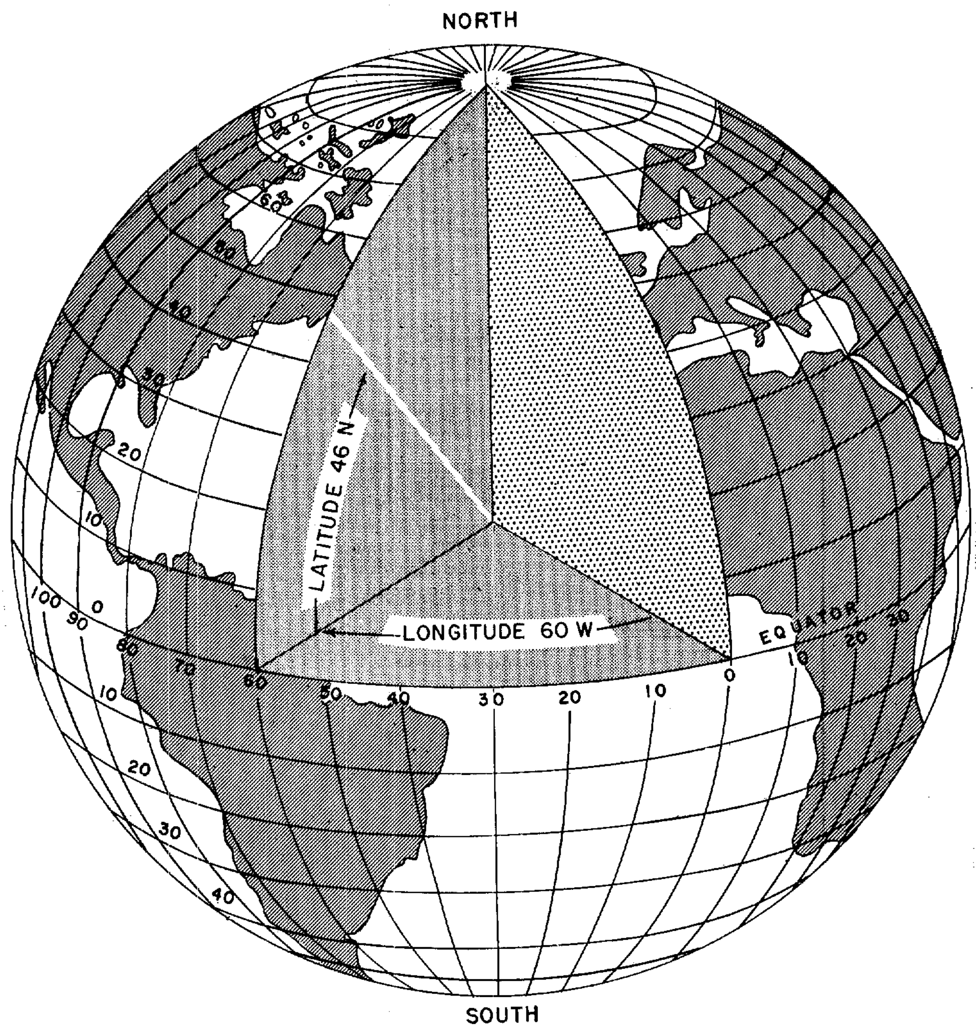

Figure 5. Geographic coordinates.

Geographic coordinates generally are used to locate points on a map when the map does not include a military grid. When a point falls between meridians and parallels on a map it often is more difficult to interpolate its exact position than when using military grids. Geographic coordinates are most often used when reading medium or small scale maps that do not contain a military grid. Many medium scale maps (scales from 1:100,000 to 1:900,000) and most small scale maps (smaller than 1:1,000,000) do not contain a military grid, and at these smaller scales the quality of great accuracy does not exist. In these cases geographic coordinates can be estimated or measured quickly, since an approximation is all that can be expected.

2. Kinds of Measurements. Just as there are different origins for longitude, so there are different methods of representing geographic coordinates. There are two methods of dividing a circle into its smaller parts. The degree system was used above in the determination of latitude and longitude distances from the zero lines. This is called the sexagesimal system, which is based upon divisions of 60.

a. Sexagesimal System. The whole sexagesimal numbering system evolved from ancient observation of, and reverence for, heavenly bodies. The ancients noted that the moon waxed and waned every 30 days. The time between two full moons was called a "moonth." Twelve "moonths" (months) elapsed from spring to spring. This completed cycle or circle, or 30 x 12, made 360. All circles were divided accordingly. Sixty was an even multiplier or divider of 12 and 360, so was used to represent the number of units in one degree and in one minute. Thus, one degree contains 60 minutes, and one minute contains 60 seconds. The sexagesimal system became the basis for the English units of measurements for many things besides a circle.

EXERCISE III

Geographic Coordinates in Sexagesimal System

Give the geographic coordinates (in degrees, minutes, and seconds) for the following locations on the map, Figure 6:

1. Ap Tan Hoa in grid square 74. ______________________
2. Ap Phu in grid square 75. ______________________
3. Thot Not in grid square 53. ______________________
4. Thoi Lai in grid square 61. ______________________
5. Lai-Vung in grid square 63. ______________________

Give the names of the towns located at the following geographic coordinates:

6. N 10° 21' 48" E 105° 31' 36" ______________________
7. N 10° 08' 29" E 105° 27' 36" ______________________
8. N 10° 24' 12" E 105° 32' 13" ______________________
9. N 10° 19' 54" E 105° 37' 25" ______________________
10. N 10° 21' 30" E 105° 27' 12" ______________________

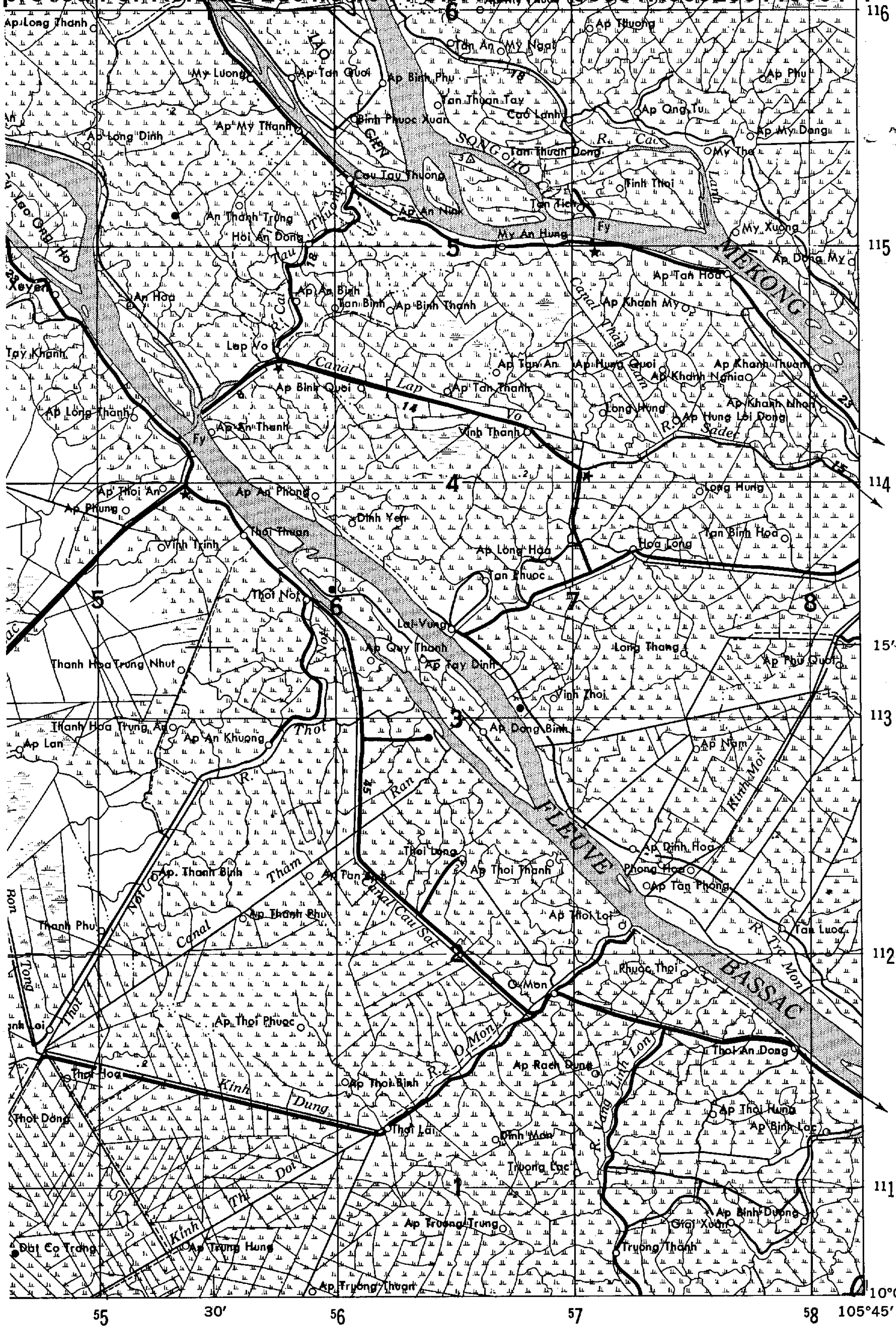

Figure 6. Map, 1:250,000.

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b. Centesimal System. Circles can be divided in another way in spite of the sanction of long usage given to 360 degrees, 60 minutes and 60 seconds. The centesimal system was originated in the 18th century. It is based on a decimal subdivision of the circle. The complete circle is divided into 400 parts called GRADS (or Grades). Each grad is divided into 100 minutes, or centigrads, and each minute into 100 seconds, or decimilligrads. Values may be written in grads, minutes and seconds or merely in grads and a decimal fraction. For example: 4 grads, 97 minutes, 30 and 25 hundredths seconds equals $4^G\ 97^{`}\ 30.25^{``}$ or $4.^G973025$. (Note that minute and second symbols slope in the reverse direction of sexigesimal symbols.)

* * *

EXERCISE IV
Geographic Coordinates in the Centesimal System

(Questions apply to map, Figure 7.)

1. What are the geographic coordinates (in grads, based on Paris) for the center of Sontay?

2. Give the geographic coordinates for the road junction located at grid coordinates 563338.

3. What are the geographic coordinates for the bridge at grid coordinates 599278?

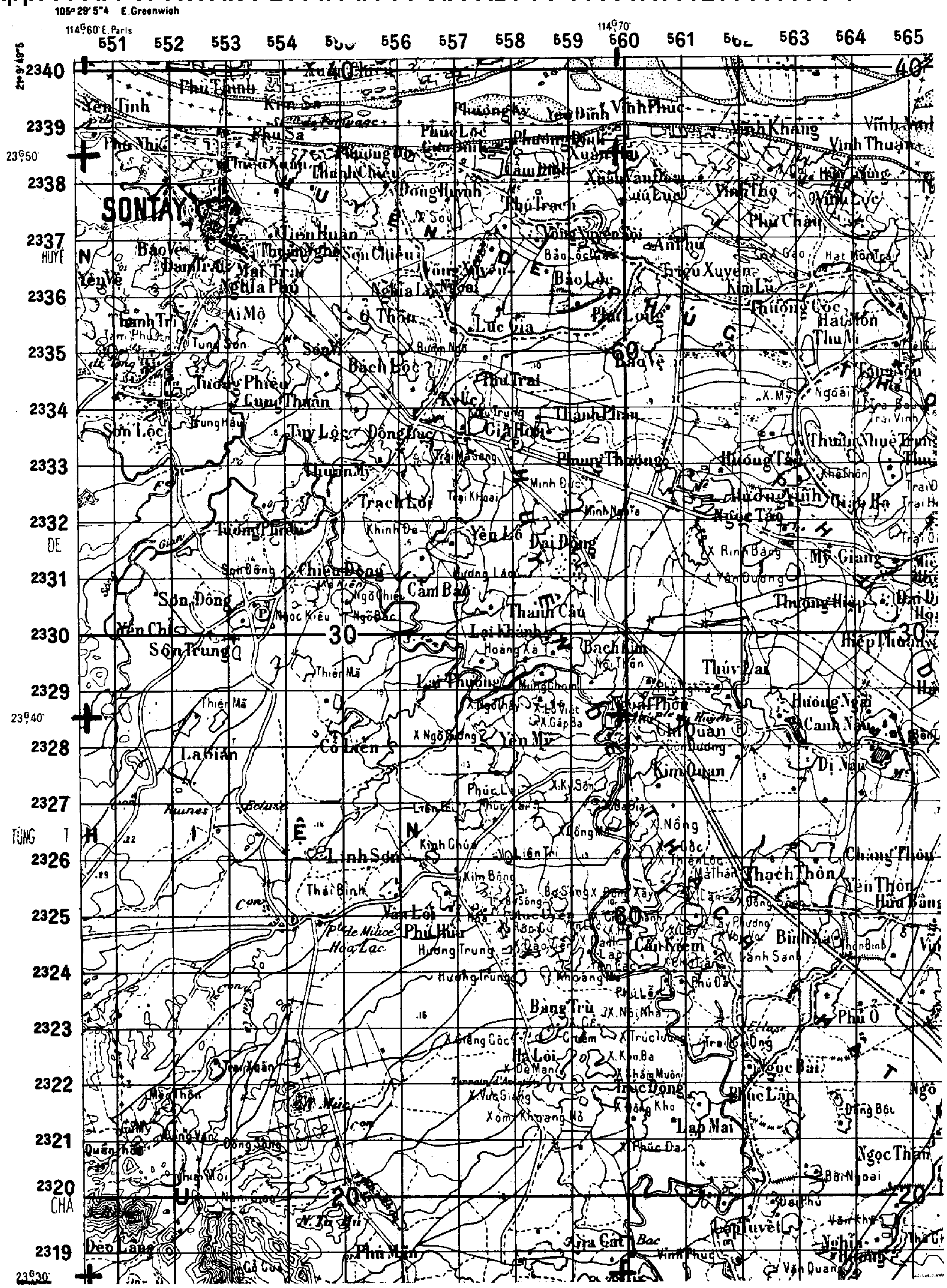

Figure 7. Map, 1:100,000.

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c. Conversion from One System to the Other. To convert from the centesimal to the sexagesimal system, or the reverse, work on the basis of a quadrant (one-fourth circle) which equals 100 grads or 90 degrees. Thus, one grad equals 9/10 (0.9) degree and one degree equals 10/9 grads.

Example: To convert $4^G\ 97^{`}\ 30.25^{``}$ to degrees, minutes and seconds:

$4^G\ 97^{`}\ 30.25^{``} = 4.973025$
$4.973025 \times 0.9 = 4.4757225$ or $4^\circ\ .4757225$
$.4757225 \times 60$ minutes $= 28.54335$ or $4^\circ\ 28.54335'$
$.54335 \times 60$ seconds $= 32.601$ or $4^\circ\ 28'\ 32.601''$

Example: to convert $4^\circ\ 28'\ 32.601''$ to grads:

$32.601'' \div 60 = 0.54335'$
$28' + 0.54335' = 28.54335'$
$28.54335' \div 60 = 0.4757225^\circ$
$0.4757225^\circ + 4^\circ = 4.4757225^\circ$
$$\frac{4.4757225^\circ}{1} \times \frac{10}{9} = \frac{44.757225}{9}$$
$44.757225 \div 9 = 4.973025$ or $4^G.973025$ or $4^G\ 97^{`}\ 30.25^{``}$

EXERCISE V
Converting Geographic Coordinate Systems

Convert the following centesimal coordinates to the sexagesimal system:

1. N $12^G.2363$ E $106^G.1407$

2. N $47^G 51^{`} 00.0^{``}$ W $1^G 08^{`} 12.6^{``}$

3. S $3^G\ 86^{`} 40.126^{``}$ W $66^G\ 19^{`} 01.006^{``}$

Convert the following sexagesimal coordinates to the centesimal system:

4. N $43^\circ 15'$ E $16^\circ\ 59'$

5. S $15^\circ\ 28'\ 43''$ E $125^\circ\ 52'\ 12''$

6. N $85^\circ\ 13'\ 57.11''$ E $176^\circ\ 04'\ 00.00''$

d. Prime Meridians. When reading longitude values from a map based on a prime meridian other than the Greenwich meridian, it is necessary to convert to Greenwich values before reporting the coordinates. To convert longitude to Greenwich, add or subtract the longitudinal distance between the prime meridian of the map and the Greenwich meridian. This longitudinal distance is often printed on the map, or it can be determined by consulting the following table:

Table I. Longitudinal Distances of Various Prime Meridians from Greenwich.

	°	'	"	
Amsterdam	4	53	05	E
Athens	23	42	59	E
Batavia	106	48	28	E
Bern	7	26	20	E
Brussels	4	22	13	E
Copenhagen	12	34	40	E
Ferro (French value)	17	39	46	W
(German value)	17	40	00	W
Istanbul	28	59	20	E
Lisbon	9	07	00	W
Madrid	3	41	15	W
Moscow	37	34	15	E
Oslo	10	43	23	E
Padang	100	22	01	E
Paris	2	20	14	E
Peking	116	28	10	E
Pulkovo	30	19	38	E
Rome	12	27	08	E
Singkawang	108	59	41	E
Stockholm	18	18	30	E
Tokyo	139	44	41	E

If the prime meridian is east of Greenwich, add the difference to convert to Greenwich values. If the prime meridian is west of Greenwich, subtract the difference to determine Greenwich values. For example: the Paris meridian is 2° 20' 14" East of Greenwich. To convert a longitude of E 68°13' 29" based on Paris to Greenwich, add the longitudinal distance between Greenwich and Paris--E 68°13' 29" + 2° 20' 14" = 70° 33' 43" East of Greenwich. However, if the longitude of a point is less than the difference between Greenwich and the prime meridian, and in the opposite direction, the Greenwich value will be the longitude of the point subtracted from the difference between the prime meridian and Greenwich. For example: if the longitude of a point is W 2°16' 12", based on Istanbul, it will have a Greenwich value less than the difference between Istanbul and Greenwich. E 28° 59' 20" (Greenwich) minus W 2° 16' 12" (Istanbul) equals E 26° 43' 08" (Greenwich). (See Figure 8.) Since latitude is always based on the equator, no conversion is necessary for that portion of the coordinates. On maps expressing geographic coordinates in grads and a prime meridian other than Greenwich, the coordinates must be converted to degrees, minutes, and seconds before converting to the Greenwich meridian.

To convert longitude from Greenwich to another prime meridian, the reverse procedure is employed--subtract the difference if the other meridian is east of Greenwich, and add if it is west of Greenwich. It is advisable to diagram the relationship between the local prime meridian and the Greenwich meridian and the longitude of the point to be converted, as in Figure 8. This will make clear the east and west values and whether to add or subtract.

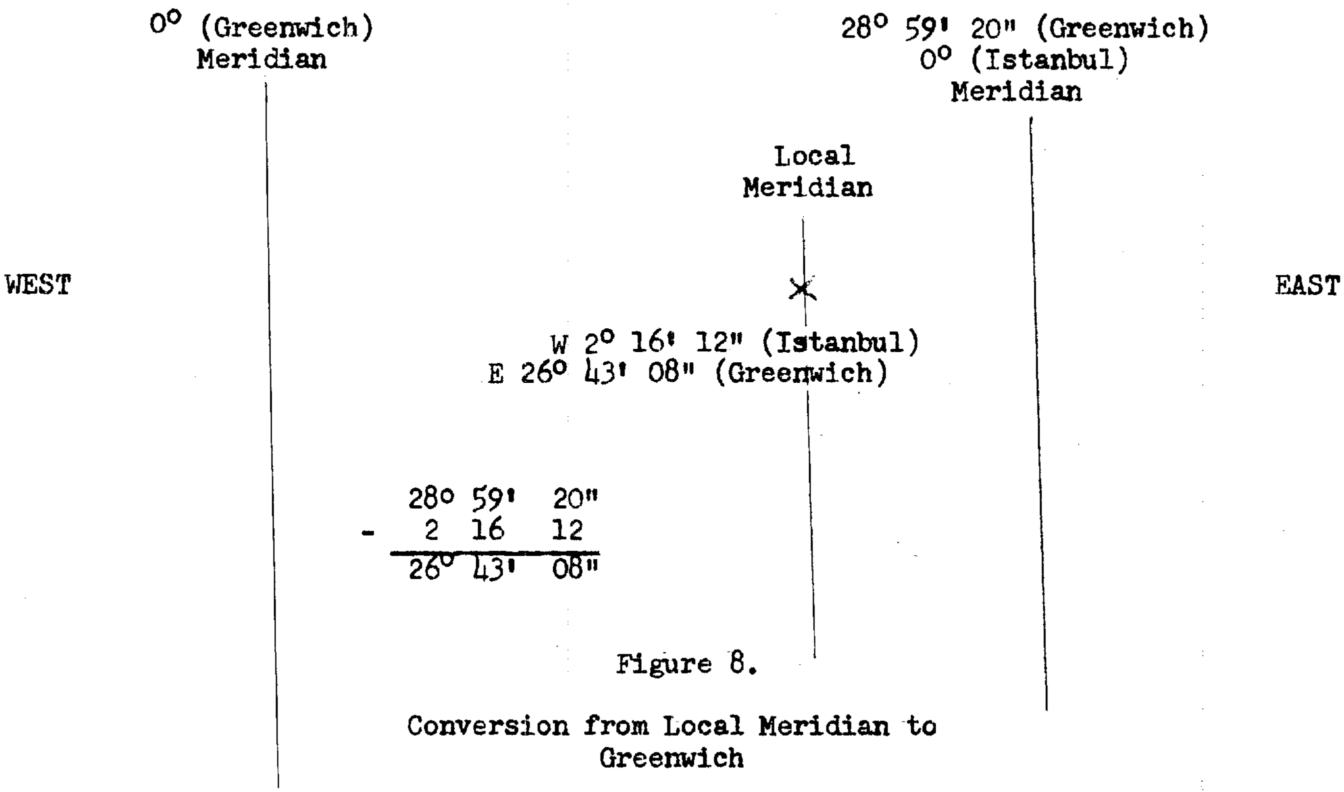


Figure 8.

Conversion from Local Meridian to Greenwich

EXERCISE VI
Converting Geographic Coordinates

Convert the following geographic coordinates to Greenwich values:

1. N 8° 13' E 60° 47' (based on Ferro, German value)
2. N 38° 06' 27" E 15° 31' 59" (based on Rome)
3. N 62° 14' 23" E 65° 42' 48" (based on Moscow)
4. S 22° 14' 38" W 32° 53' 26" (based on Lisbon)
5. S 9° 47' 04" E 18° 31' 45" (based on Batavia)
6. N 40° 16' 00" W 2° 11' 00" (based on Athens)
7. N 32° 14' 38" E 1° 34' 53" (based on Madrid)

Convert the following geographic coordinates to the sexagesimal system and Greenwich values:

8. N 20^{G} 12` 06`` E $118^{G}$ 19` 51`` (based on Paris)
9. N 15^{G} 59` 07`` W $14^{G}$ 20` 26`` (based on Paris)
10. N 44^{G} 44` 10`` E $14^{G}$ 63` 89`` (based on Istanbul)

C. USE OF COMPASS

1. Description and Use. A compass is an instrument for measuring directions. It contains a pointer which always points in a northerly direction. The face of the compass, under the pointer, is circular and calibrated in either "compass directions," 360 degrees, or 400 grads, mills, or bearings. A military compass usually has a front sight and a rear eyepiece to aid in lining up the compass on a distant object. A lensatic compass has a magnifying lens to aid in reading the numbers on the dial while it is held close to the eye. Prismatic compasses contain a prism instead of a magnifying lens.

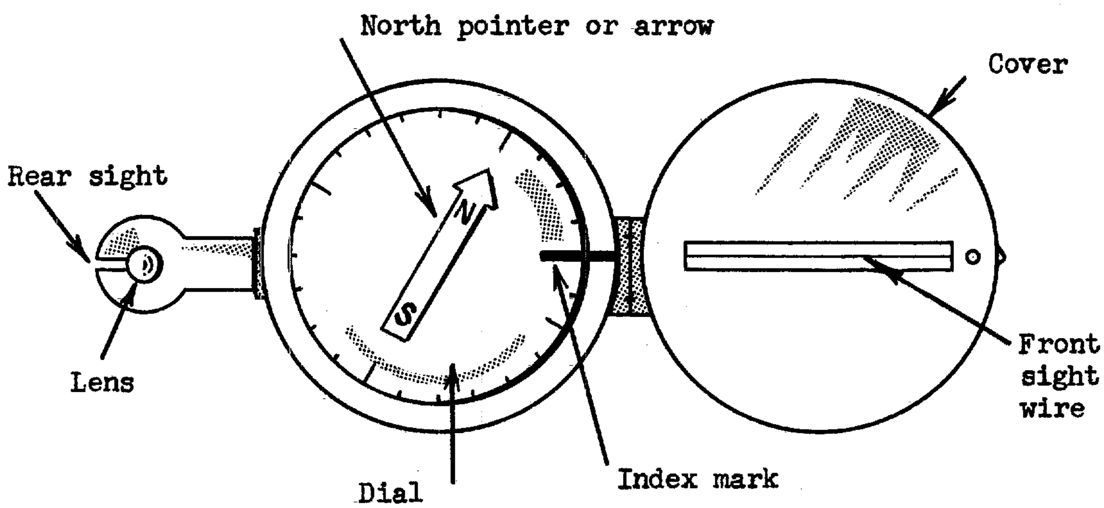


Figure 9. Lensatic Compass

A compass is held as steady as possible in front of the body (the lensatic compass is held close to the eye) with the front of the compass pointed toward the desired object until the pointer stops moving. The dial of the military compass will turn with the pointer so that the angular direction can be read directly under the index mark at the front of the compass. A hand compass usually can be read to an accuracy only of two degrees. Since any object made of iron will attract the compass pointer, be sure to keep an adequate distance from any such local disturbance. Power lines and telegraph lines also will deflect the compass from an accurate reading. This attraction can be demonstrated by holding a compass close to an iron object or near a power line.

EXERCISE VII
Use of Compass

Using the compass available to you, determine the angular direction of at least six objects within sight of your location.

2. Use of Compass at Night. Some compasses are designed so that they can be used at night without a light. One type contains under the transparent dial an area coated with luminous paint which makes the numbers of the dial visible in darkness. Another type has luminous dots to mark the front sight and points on the compass body corresponding to 90°, 180°, and 270°. The glass covering the dial will rotate with a series of clicks, each click equal to three degrees. This glass contains a luminous index line. The pointer is also luminous. To read angular directions at night with this type compass, hold it and sight on the desired object in the normal manner, then, holding the instrument steady, slowly turn the glass dial cover in a counterclockwise direction, counting the clicks, until the luminous index mark falls over the luminous pointer. The number of clicks counted times three degrees will equal the desired angle.

For example: be sure the luminous index line is set to fall exactly over the fixed index mark at the front of the compass dial, then sight the compass on an object. Holding the compass steady, turn the cover glass in a counterclockwise direction until the luminous index line falls over the luminous pointer and count the number of clicks (in this example, assume 10 clicks). Since each click equals three degrees, 10 clicks equal 30 degrees, which is the angle of the object.

EXERCISE VIII
Using Compass at Night

Practice the above procedure in the dark until you can read directions quickly and accurately.

* * *

3. Declination Determination.

a. True North. Determination of any location is always relative to some frame of reference. For example, longitude is determined from the prime meridian, latitude is determined from the equator, elevation is determined from sea level. The north pole is an imaginary point in the arctic toward which all the meridians converge. This point is a convenient reference in determining the north direction. The direction of the meridians is easy to determine because each meridian intersects the path of the sun at a right angle (90 degrees). Therefore, by following any meridian northward to the north pole a specific point is reached which is north of every other point on the earth. This is the north direction, or true north, referred to when using geographic coordinates.

b. Magnetic North. Use of a compass to determine directions requires a different reference point because the compass pointer does not point exactly to the north pole, but to a point near the north pole usually located in northern Canada. This magnetic pole is not stationary but moves constantly within a limited area. Since the geographic north pole and the magnetic pole are not located at the same place, from most locations on the earth the compass will point either to the east of the north pole or to the west of it. (See Figure 10.) This difference between true north and magnetic north, called magnetic declination, varies from zero degrees at some places on the earth to more than 90 degrees in some higher latitudes, and must be referred to as east declination or west declination. If the compass points to the east of true north, it is east magnetic declination; if the compass points to the west of true north, it is west magnetic declination. Maps usually contain a note indicating the amount of annual change in magnetic declination.

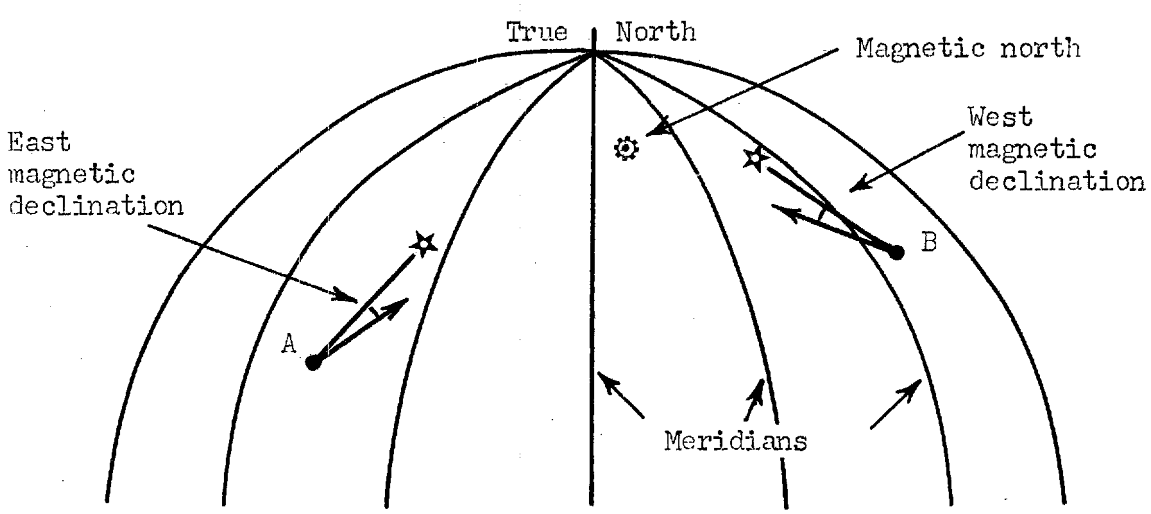


Figure 10.
East and West Magnetic Declination

c. Grid North. The third north direction indicated on maps is grid north. This is the direction indicated by the vertical grid lines. Grid lines are straight and meridians are curved; therefore they get farther apart as the lines are extended north from the equator. Grid declination is the angular distance between the vertical grid lines and the meridians (See Figure 11.) Grid north is constant for each grid zone but may be different on different maps. Along the central meridian of each grid zone grid north and true north are the same and there is no grid declination since the central grid line falls on the central meridian of the zone. Along all other meridians there will be an east or west grid declination. Magnetic north usually does not correspond with grid north. Although the relationship of true north to grid north remains constant for each point, the relationship between magnetic north and grid north is not constant, since the magnetic declination gradually changes each year. The grid-magnetic declination for any year can be determined by consulting the information printed on each map.

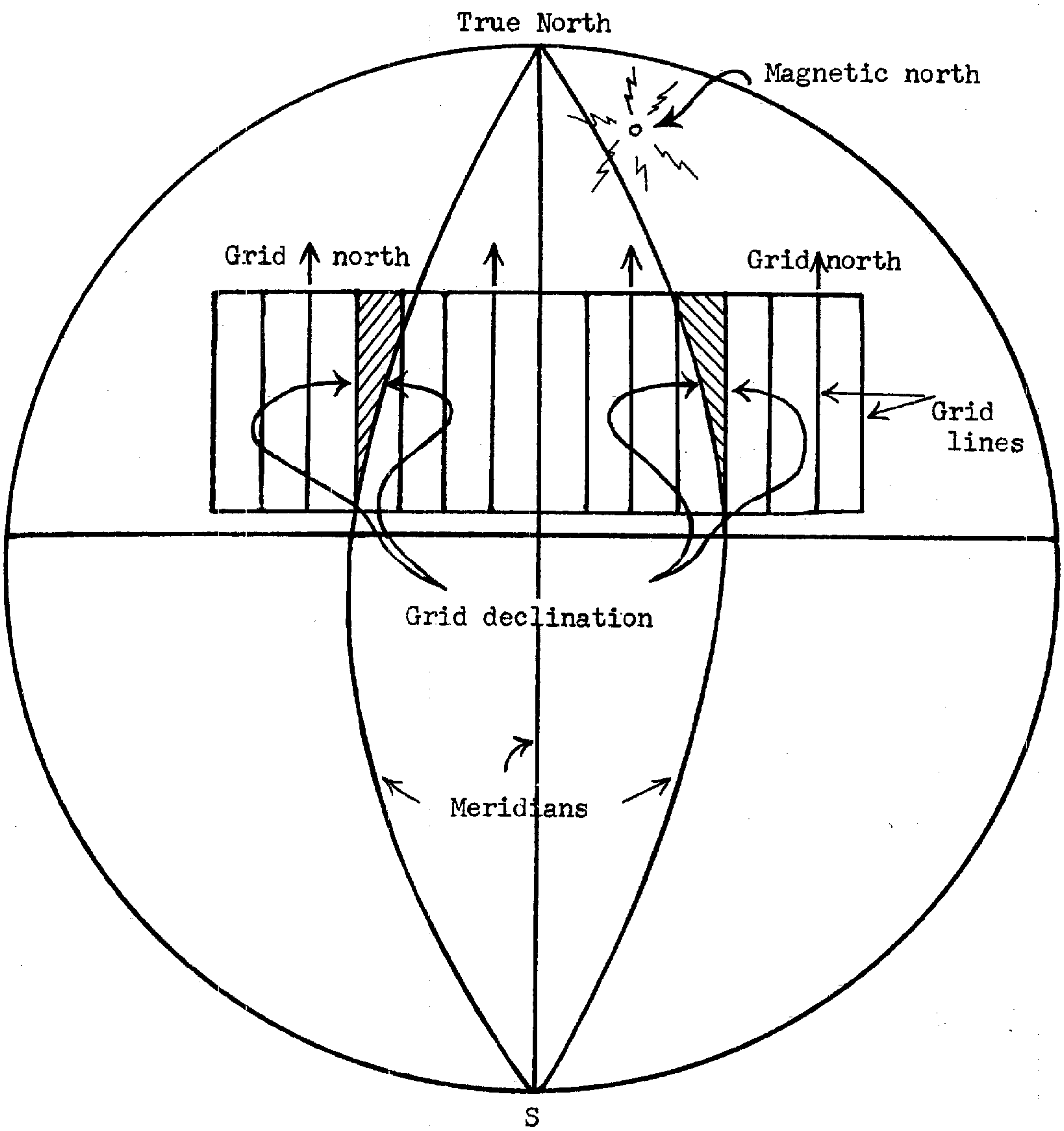
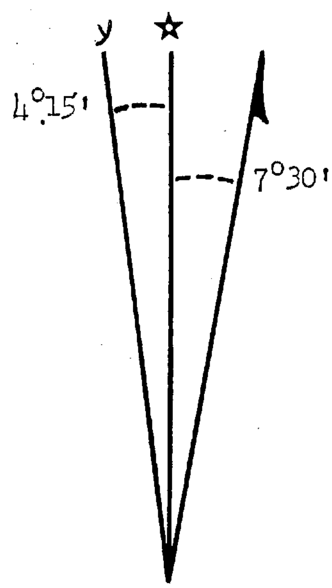


Figure 11. Grid declination.

d. Declination Diagram. A declination diagram appears on most maps to show the relationships among true north, magnetic north, and grid north. The diagram consists of three lines; a star indicates the true north line, an arrow indicates the magnetic north line, and a Y or initials indicate the grid north line. At the sides of the diagram are numbers indicating the amounts of grid declination and magnetic declination, expressed in degrees or grads. The declination angles are not always drawn accurately in the diagram so it is important to refer to the size of the angles as expressed by the numbers. The declination, as expressed by the diagram, will usually be different for each map sheet. Often below the diagram will be a note indicating the amount of annual magnetic change, westerly or easterly, and the year for which the diagram is drawn.



Declination for 1955
Annual Magnetic Change 6' Westerly

Figure 12.
Declination Diagram

To determine the grid-magnetic angle for a map from the declination diagram, add or subtract from the magnetic declination the amount of annual magnetic change times the number of years since the date of the diagram, and subtract from or add to the amount of the grid declination.

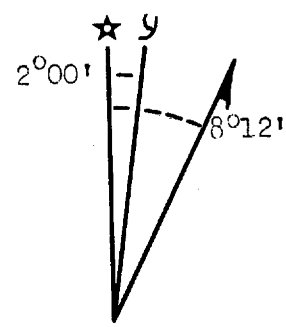
Example: Use the diagram in Figure 12 and determine the grid-magnetic angle for 1958

7° 30' - 18' = 7° 12'
7° 12' + 4° 15' = 11° 27', the grid-magnetic angle

In this example the change for three years (18') is subtracted because the change is westerly.

Example: Determine grid-magnetic angle for 1958.

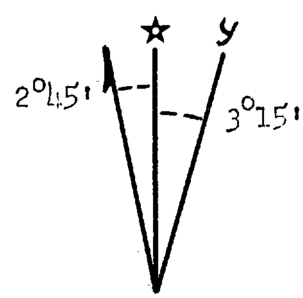
3' x 8 years = 24'
8° 12' + 24' = 8° 36'
8° 36' - 2° = 6° 36', the grid-magnetic angle



1950 - Annual Change 3' Easterly

Example: Determine grid-magnetic angle for 1959.

1' x 14 years = 14'
2° 45' - 14' = 2° 31'
2° 31' + 3° 15' = 5° 46'



1945 - Annual Change 1' Easterly

e. Converting Declinations. Tactical use of a map containing a military grid usually involves converting all compass readings to grid values. To avoid making a computation for each reading, the movable index mark on the compass can be set to the proper number of degrees east or west of the fixed index mark, and then angles based on the grid can be read directly under the movable index mark.

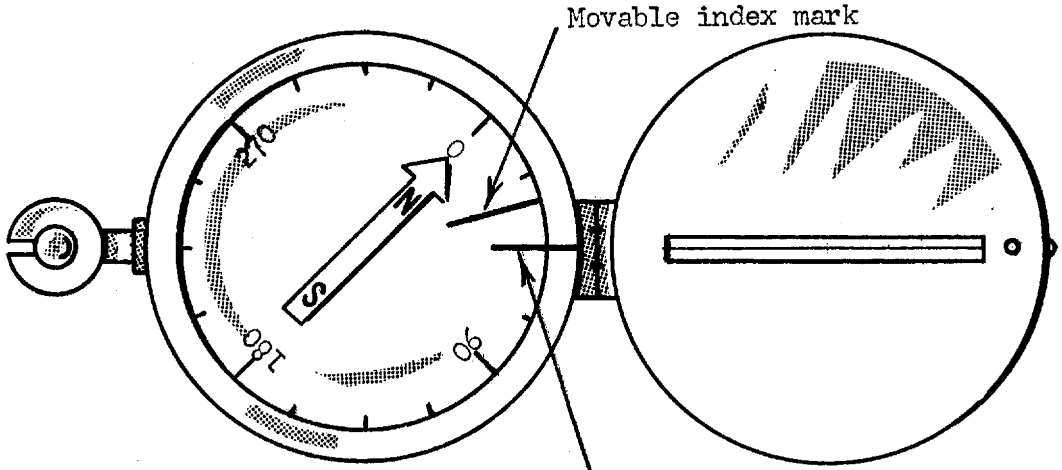


Figure 13.

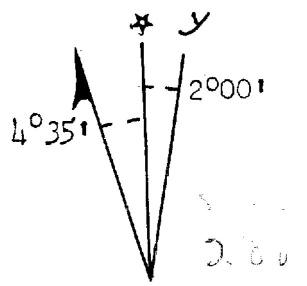
Shows the movable index mark set for reading grid values directly when the grid-magnetic angle is 12°, and grid north is west of magnetic north.

The compass is sighted in the usual manner. Similarly, compass readings can be converted to true directions by using the magnetic declination angle in the manner described above.

EXERCISE IX
Declination

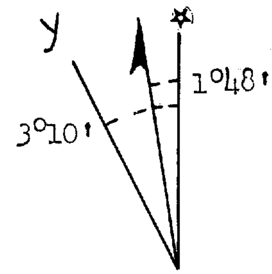
From the following declination diagrams, determine the magnetic declination and the grid declination for 1960.

1.



1955
Annual change 8' Easterly

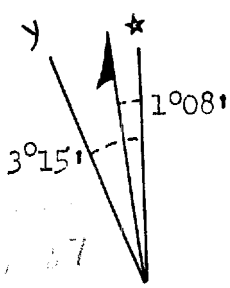
2.



1950
Annual Change 2' Westerly

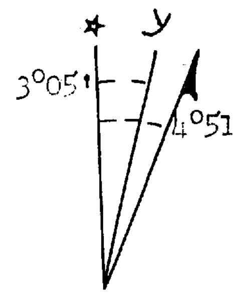
From the following declination diagrams, determine the grid-magnetic angles for 1959.

3.



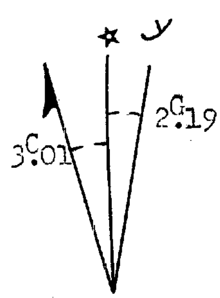
1948
No annual change

4.



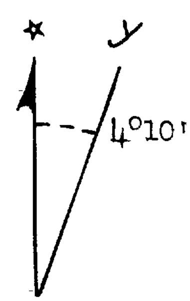
1956
Annual change 5' Westerly

5.



1946
Annual change $0^G.093$ Easterly

6.



1958
Annual change 6' Easterly

Approved For Release 2001/04/04 : CIA-RDP78-03581R000200110001-4

4. Azimuth and Back Azimuth. The azimuth is a method of indicating direction in military map reading. An azimuth is a horizontal angle measured clockwise from a north reference line. The point from which the direction is measured is presumed to be at the center of an imaginary horizontal circle. This circle is divided into units of degrees, grads, or mils. The units are numbered in a clockwise direction with the zero point at the north. If the circle is divided into degrees, zero degrees and 360 degrees will be at the north, 90 degrees will be due east, 180 degrees will be to the south, and 270 degrees will be due west. Direction by the azimuth method is expressed by giving the number of the degrees on the circle at which a line, drawn from the initial point through the point desired, will pass. The azimuth from the observer to an observed position is known as the forward azimuth to that point. However, every observed line of sight has a forward azimuth and a back azimuth. The back azimuth of any line varies from its forward azimuth by exactly 180 degrees. To determine the back azimuth of a line whose forward azimuth is less than 180 degrees, add 180 degrees. If the forward azimuth is greater than 180 degrees, subtract 180 degrees.

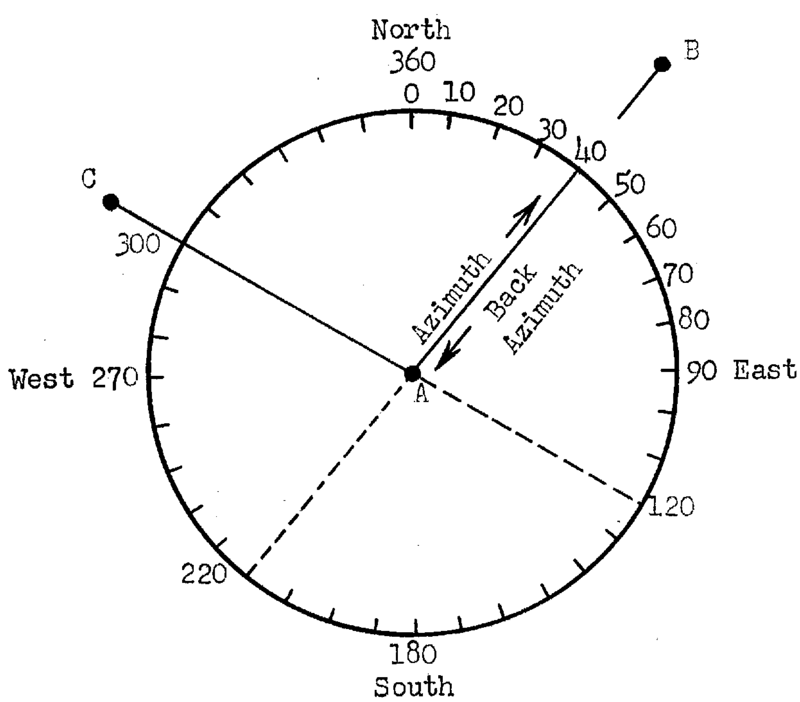


Figure 14.
Azimuth and Back Azimuth

In Figure 14 the azimuth of point B is 40 degrees. Therefore, the back azimuth of point B is 40 plus 180, or 220 degrees. The azimuth of point C is 300 degrees. Its back azimuth is 300 minus 180, or 120 degrees.

Azimuth can be determined by reading the angle directly from the lensatic compass, and it would then be magnetic azimuth. If the movable index mark of the compass is first set to correct for the magnetic declination of that locality, the reading would be true azimuths. If the grid-magnetic angle is set into the compass, the reading will be expressed in grid azimuths. When reporting azimuths to other persons it is important to indicate the kind of azimuths--magnetic, true, or grid.

If a night patrol wishes to move to a nearby hill and return, its outward course will be along the azimuth to the hill as determined from the starting point. Then, when the patrol is ready to return it is not necessary to take a new reading on the starting point, which may not be visible, because the return course will be the back azimuth of the outward course.

When using a compass calibrated in grads, back azimuth is determined by adding or subtracting 200 to or from the azimuth. This figure is used because 200 grads equal one-half circle.

EXERCISE X
Azimuth and Back Azimuth

What are the azimuths (in degrees) of the four cardinal points of the compass?

1. North

2. East

3. South

4. West

Give the back azimuths of each of the above azimuths.

5.

6.

7.

8.

Determine the back azimuths for the following azimuths:

9. 63^{o}

10. 45^{G}

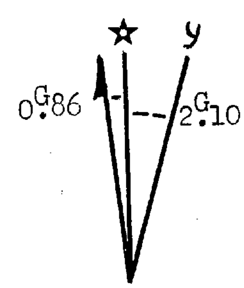
11. 261^{o}

12. 389^{G}

13. What is the back azimuth (true) of 180^{o} magnetic azimuth if the magnetic declination is 14^{o} east?

14. Determine the grid back azimuth of 250^{o} magnetic azimuth when the grid-magnetic angle is 6^{o} 15' and grid north is west of magnetic north.

15. Give the magnetic back azimuth of grid azimuth 105^{G} determined from a map with this declination diagram:



5. <u>Intersection.</u> Intersection is the method of locating an unknown, unoccupied point by taking sights to the unknown point from at least two known occupied positions. To determine the exact location of a point that is not on the map, move to a terrain feature, A (Figure 15) which can be identified on the map, and take a compass sight on the object, C, you wish to locate. Move to another identifiable feature, B, and again sight on the object C with your compass. Then change the magnetic azimuths to grid azimuths and plot the grid azimuths through the respective positions where you obtained the sights, or draw a magnetic north reference line through points A and B on the map and plot the magnetic azimuths. (Figure 16) The intersection of the two lines is the location of the object.

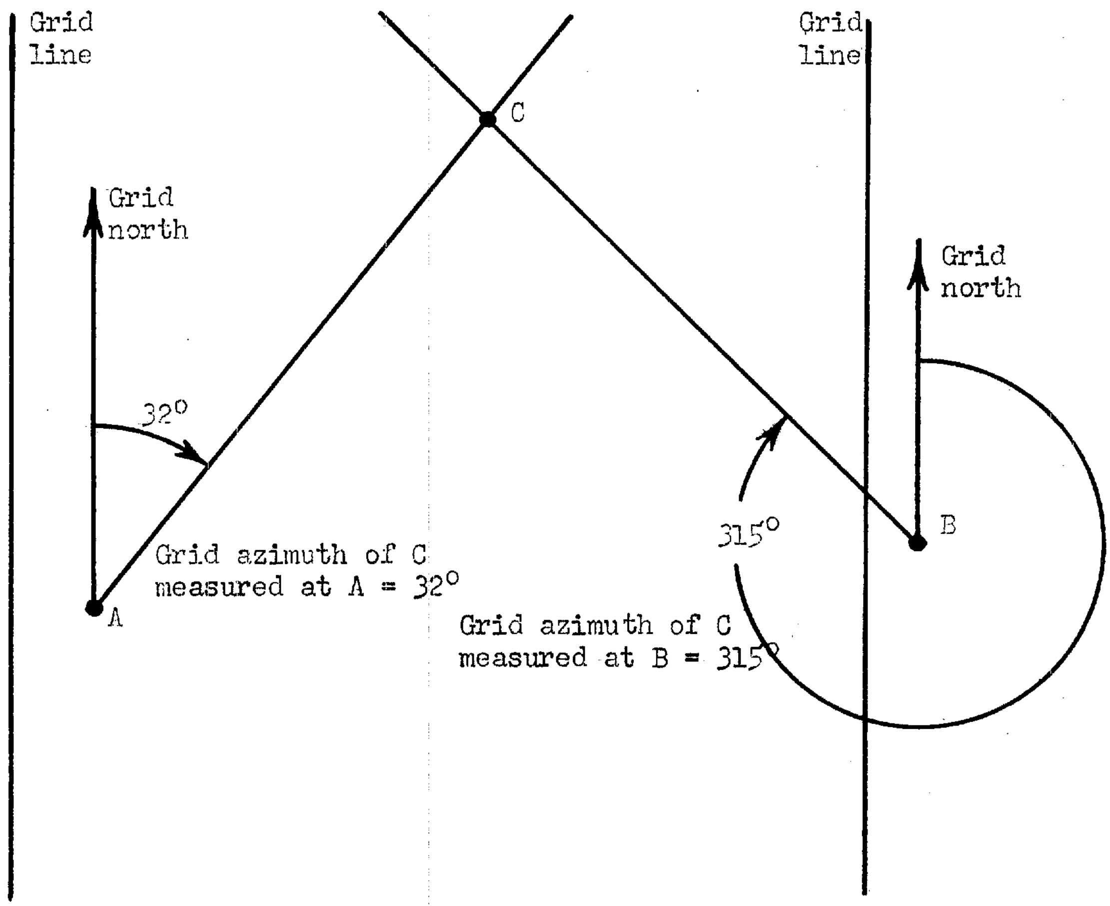


Figure 15.
Intersection using Grid Azimuths

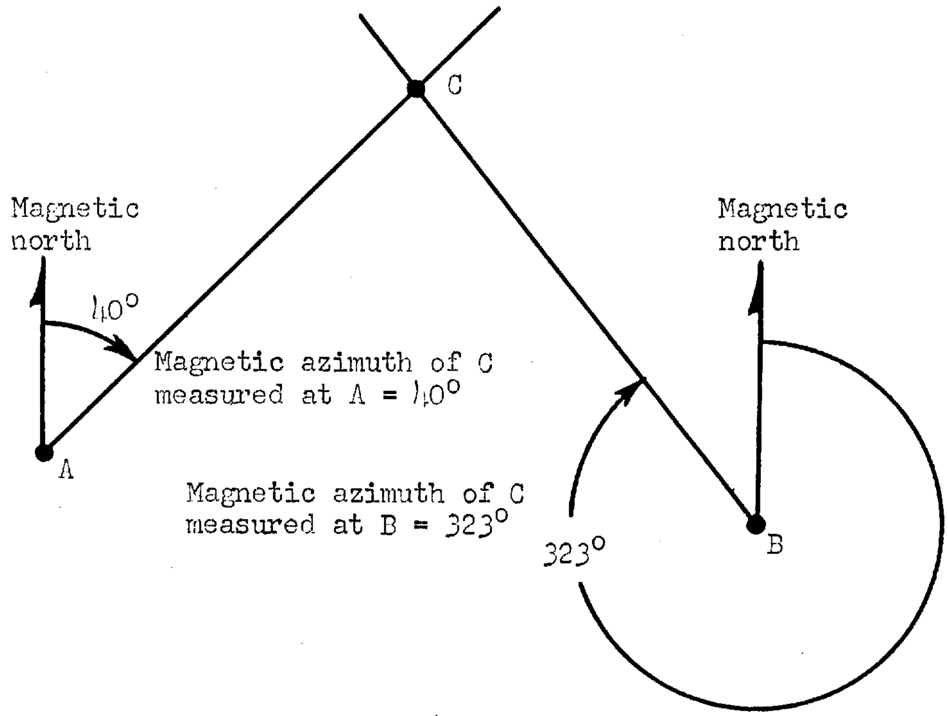


Figure 16.
Intersection Using Magnetic Azimuths

EXERCISE XI
Intersection

1. Using the protractor in Appendix A in place of a compass, determine the grid coordinates of the point on the map in Figure 3. described in the following intersection problem: From grid location 40200270 an object is seen on a grid azimuth of 284°, from grid location 39750422 the same object is seen on a grid azimuth of 235°. What are the grid coordinates of the object? ________________

2. From grid location 37420174, an object is seen on a magnetic azimuth of 70°; from grid location 40120050 the same object is seen on a magnetic azimuth of 345°. The grid magnetic angle of this map is 4°, with grid north east of magnetic north. What are the grid coordinates of the object? ________________

6. Resection. Resection is the method of locating an unknown occupied position by taking sights on two or more identifiable points whose positions are known. To determine the location of the position you are occupying, select two visible objects which can be identified on the map and which are situated so that lines from you to them make an angle greater than 30 degrees and less than 150 degrees. With the compass determine the magnetic azimuths to both points A and B (Figure 17). Draw magnetic north guide lines through the map positions of each object, A and B. From points A and B lay off the respective magnetic azimuths and extend these lines back towards your position until they meet. The intersection of these lines is the location you occupied while measuring the azimuths with the compass.

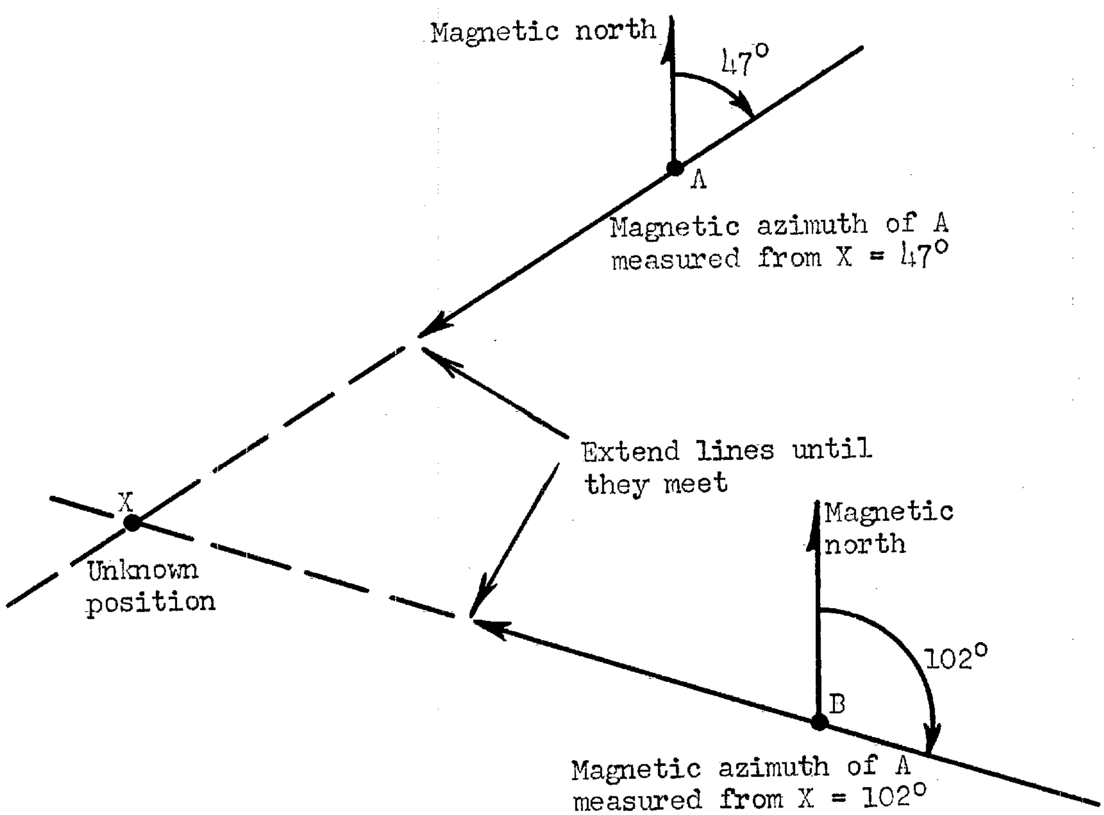


Figure 17.
Resection Using Magnetic Azimuths

EXERCISE XII
Resection

1. You are located somewhere on the map, Figure 40, and want to determine your exact position. The cluster of buildings at 832717 at the top of the bluff can be seen on a grid azimuth of 153 degrees. The point where the road crosses Ihagee Creek in grid square 8072 is seen on a grid azimuth of 254 degrees. What are the coordinates of your location?

* * *

7. The Compass Course. When it is necessary to move from one point to another, there is not always a convenient road directly connecting the two points. One method of finding your way along a predetermined route without going too far out of your way is to follow the direction indicated by your compass. Even if the course leads you through forests, over mountains, or across rivers, you can arrive at your destination by travelling in the predetermined direction shown by your compass. Military units often need to travel in the most direct route or desire to keep off the roads, and they can do this by following a compass course.

The compass course to follow can be determined by reading the azimuth of the destination directly with the compass, if the destination is within sight of the starting point. The azimuth to follow to the objective can be measured directly from a map, if one is available, and both the starting point and the destination can be identified on the map.

It usually is necessary to determine exactly how far to travel on the given azimuth to arrive at the destination. When travelling on foot the most practical method of determining distance is to count the number of steps or strides. A step or pace is the distance travelled with one foot while walking naturally. A stride is the distance between the heel of one foot and the point at which the same heel meets the ground again while walking. It is equal to two steps. The length of a person's pace or stride can be determined by walking a measured distance many times and taking the average count. A suitable course for determining one's average pace or stride should be at least 100 meters long and over approximately level terrain with normal ground cover. Remember that a step tends to be shorter going up or down hill.

When ascending slopes up to 40%, the horizontal distance travelled per stride or pace will average 1.2% less for each percent of slope. For example, if you walk up a 10% slope, after 100 strides you still would have to take an extra 12 strides to cover the same horizontal distance you would walk in 100 strides on a level. When descending slopes up to 30%, the horizontal distance travelled will average 0.5% less for each percent of slope. For example, in descending a 20% slope you would have to take 110 strides to cover the horizontal distance equivalent to 100 strides on a level. This assumes, of course, that you continue to walk in a normal manner and do not attempt to maintain a uniform stride on different slopes. The character of the ground surface, such as sand, rocks, short or high grass, smooth or rough, soft or hard, trees or brush, will affect the length of the step. Other factors having an effect on the length of pace are wind, the elements, clothing, and personal stamina. Each of these factors must be taken into consideration when pacing a distance. Sometimes extreme conditions, such as dense vegetative cover, can make accurate pacing impossible without clearing a path.

There are two common causes for error in pacing distances. It is a natural human tendency to overestimate distances when walking. Also, when measuring distances from a map, horizontal distances are obtained. The distance along the ground in hilly terrain may be considerably greater than the horizontal map distance.

When pacing over extended distances, keeping track of the steps or strides becomes a problem. It usually is easiest to count by hundreds and record each hundred strides by placing small objects (sticks or pebbles) into an empty pocket. If it is important to measure short distances very accurately, the course should be paced several times in both directions to arrive at the average.

Obstructions along a compass course can be by-passed by walking at right angles (90 degrees) to the course a sufficient distance, then continuing parallel to the course until past the obstruction, and finally returning at right angles to the course the same distance previously recorded. (See Figure 18.) Do not include the paces taken at right angles to the course in computing the distance travelled along the course.

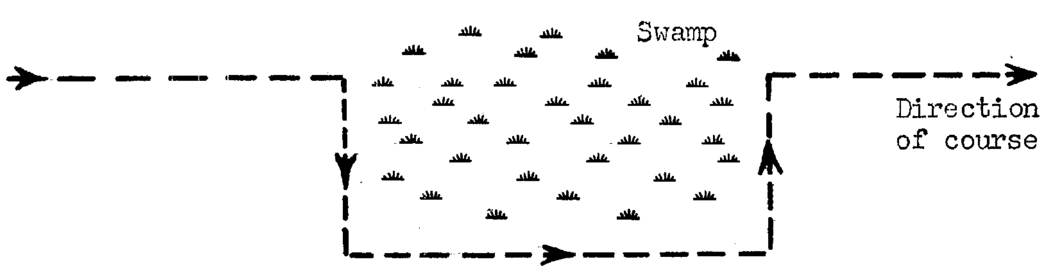


Figure 18.
By-passing Obstruction on Course

If the destination cannot be seen while travelling a compass course, care must be taken to avoid drifting off the course to the right or left. The direction of travel should be noted with the compass. Then observe two objects, such as trees, along the route which you can sight on and keep lined up as you walk. (See Figure 19.) When you reach the first object, stop, use your compass and note a new object beyond the second one. You can then walk to the second object keeping it lined up with the third, when the process is repeated. This procedure enables you to walk without constantly keeping your eyes on the compass. Even though you keep the compass pointed on the correct azimuth, there is danger of your walking slightly to the side and arriving considerably off course. If several persons are travelling a compass course together, two can move ahead and be lined up on the course by the third person with the compass. The first two then stand still while the third person walks to the nearest one. The procedure is then repeated.

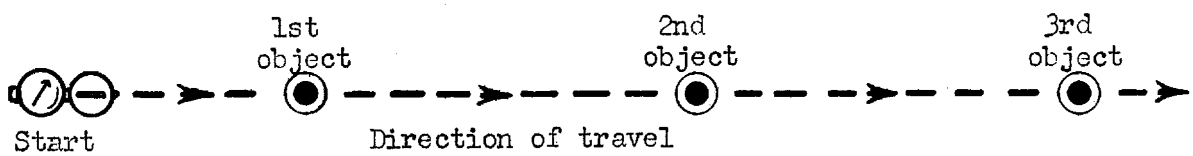


Figure 19.
Following a Course by Sighting on Two Objects

While travelling a compass course, if the destination is not visible but the starting point is visible, you can make a check to be sure you are still on the course. Determine the back azimuth of the course and sight the compass in that direction. If you are still on the course the starting point will appear in line with your compass sights. If this is not the case, move the necessary distance to the right or left until the starting point appears at exactly the back azimuth of the course.

Following a compass course at night usually is much more difficult than travel during the day. Depending on visibility, any of the principles applicable to daytime travel can be used at night. If no light is available or security prevents use of artificial light, a compass with luminous dial is necessary. Before starting, set your compass on the required azimuth by turning it until the proper azimuth appears under the fixed index mark at the front of the compass. Then, holding the compass still, set the movable luminous index mark directly over the north pointer. After setting the compass, check it carefully for accuracy. The course can then be followed by holding the compass in front of you with the front directly ahead, and keeping the luminous index mark over the north pointer. If enough natural light is available, sight on objects along the course (Figure 19) so it will not be necessary to keep your eyes on the compass.

8. Suggestions for Designing and Operating Field Compass Training Courses.

a. Select an area where students are free to move about without interference from other persons, and where power lines and other compass disturbances are not too close.

b. Design two or more courses of varing degrees of difficulty. Send students through the easiest course until they can complete it satisfactorily, before trying harder courses.

c. Each course should be composed of five or more legs, no leg to exceed 1,000 meters in length.

d. Select the path for each leg to provide a variety of terrain and obstacles, and different azimuths and distances. Select realistic terrain conditions that can be negotiated. This should not be an endurance contest. Obstacles on the course should be limited in size so that they can be by-passed as shown in Figure 18. Ordinarily a different course should be used for day and night practice.

e. Mark the end of each leg with a numbered stake that is not visible from a greater distance than 10% of the length of that leg. For example, if the leg is 500 meters long, the end stake should not be visible at a distance greater than 50 meters. This requires that the student follow the course with no more than 10% error in azimuth and distance. The quality of the compass and the difficulty of the course should determine amount of error allowed. If there is not sufficient natural cover to conceal the stake from the desired distance, locate several stakes within the 10% radius area, each with a different number. The student then will have to select the correct stake as the start of the next leg.

f. Give each student the azimuth and distance for each leg of the course. If a single stake marks each leg, instructions for the next leg can be placed at the stake. Each student should negotiate the course individually and be timed. Starting times should be at least at 15-minute intervals. Have each student record the number of the stake at the end of each leg and his distance error in arriving at it. The stakes should not be numbered in consecutive order.

g. Test each course yourself before sending the students over it, to check azimuths, distances, possible hazards, time, and degree of difficulty.

II MAP READING

A. CONVENTIONAL SIGNS

Conventional signs are a graphic method of portraying on a map the various features of the earth's surface. These map symbols usually are drawn to resemble as much as possible the actual object represented. In this way the symbol suggests the feature even to the uninitiated and thus becomes a diagrammatic picture of a portion of the earth. The standard or conventional symbols are much the same on maps produced by any country. Individual map publishers, however, may use a number of non-standard symbols that must be learned. Also, symbols used to depict military installations, units, and activities may vary considerably. But symbols for such features as streams, roads, railroads, bridges, vegetation, relief, etc., are much the same everywhere or else are self-explanatory. All non-standard symbols used on a map should be shown in the legend, but this is not always the case in practice.

For the sake of convenience and clarity, conventional signs may be divided into categories, each of which usually is printed on the map in a distinctive color. Symbols representing man-made features, administrative boundaries, and names are termed cultural symbols and are shown in black. Examples of cultural features are buildings, roads, railroads, cemeteries, dams, airfields, storage tanks, international and provincial boundaries, and names. Relief of the ground surface most commonly is indicated with contour lines printed in brown. Less precise relief symbols are hachures and shading. Green is generally used for printing vegetation symbols. Individual tree types or crops may be shown by symbols, or wooded areas may be indicated with a solid green overprint. Water features, such as rivers, lakes, shorelines, springs, swamps, and wells, are represented in blue. Other colors sometimes are added to maps to make them easier to read. Certain other features can be emphasized by printing them in color. Many maps are printed in fewer colors for the sake of economy, and it is not unusual to find maps with all conventional signs in black. A monochrome map usually is difficult to read. An example of detailed symbolization is shown in Figure 20.

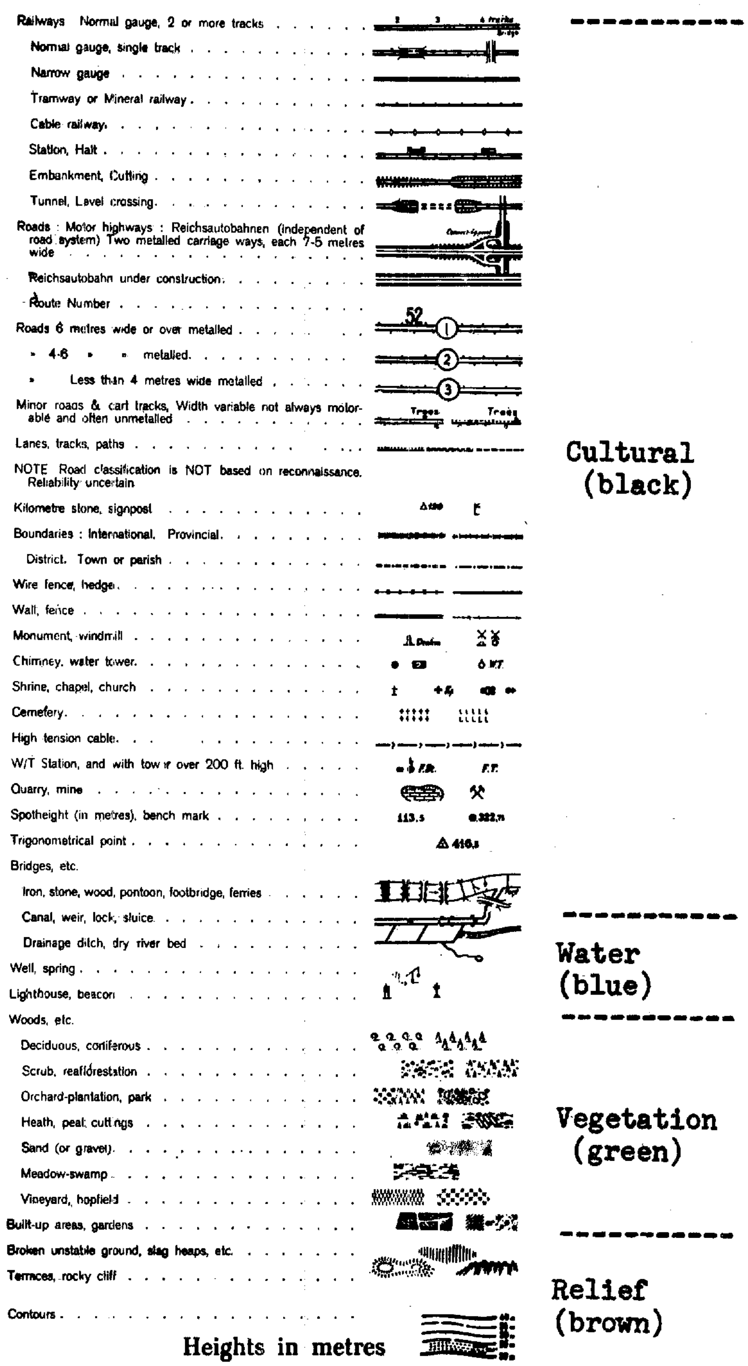


Figure 20. Legend symbols from a British map of Germany.

B. MARGINAL INFORMATION

The information printed in the margin of a map is vital to a correct interpretation of the data included within the body of the map. This information helps the user gain the proper perspective when reading the map, and provides the correct referencing for the map. The material is included to make map reading easier and more accurate, and to assist the user in his evaluation of its contents. Thus, it is strongly advisable to inspect the marginal information each time you start to use a different map. While there is a great variety in the amount of marginal information included on different map sheets, it all tends to fall into several categories.

1. The title of the map or sheet name usually is shown prominently in the upper margin in large type. Some publishers group adjacent and similar maps into series and assign a name or number to each series. Series identification usually appears in the upper margin.

2. Scale of the map is always shown and may be expressed as a ratio, a representative fraction, or as a relative distance, i. e., one inch equals one mile. Examples: 1:50,000; $\frac{1}{50,000}$; Quarter Inch (to the mile). The scale is given usually in the center of the lower margin but also may appear in the upper margin.

3. Many maps contain a glossary of generic terms appearing on the map. These terms often are presented in more than one language (See Figure 21).

GLOSSARY

VARIANTS IN PARENTHESES

-bae (-hae)	rock
-bakufu	waterfall
-bama (-hama)	beach, field
-bana (-hana)	point
-bara (-hara)	plain, field
-chō (-machi)	township
-dai (-tai)	plateau, plain
-dake (-take)	mountain
-daki (-taki)	waterfall
-dani (-tani)	valley, stream
-gan (-iwa)	rock, cliff
-gata	bay, inlet, lake
-gawa (-kawa)	river
-goe (-koe)	mountain pass
-gun	county
-guntō	archipelago
-hama (-bama)	beach, field
-hana (-bana)	point
-hantō	peninsula
-hara (-bara)	plain, field
-ike	pond
-ishi	rock, cliff
-iso	beach
-iwa (-gan)	rock, cliff
-jima (-shima, -tō)	island
-kai (-umi)	bay, gulf
-kaikyō	strait
-kawa (-gawa)	river
-ken	prefecture
-ko	lake
-kō	harbor
-koe (-goe)	mountain pass
-kojima	small isle
-machi (-chō)	township
-mine	mountain peak
-misaki (-saki, -zaki)	cape
-mori	forest
-mura	township
-nada	sea
-no	plain, field
-onsen	hot spring, spa
-rettō	island chain
-saki (-zaki, -misaki)	cape
-san (-zan, -yama)	mt. chain
-se	reef, shoal, rapid
-seto	strait
-shi	municipality, city
-shima (-jima, -tō)	island
-shō	reef, shoal
-shotō	island group
-suidō	channel
-tai (-dai)	plateau, plain
-take (-dake)	mountain
-taki (-daki)	waterfall
-tani (-dani)	valley, stream
-tō (-shima, -jima)	island
-tōge	mountain pass or ridge
-uchi	inlet
-umi (-kai)	bay, gulf
-ura	inlet, beach
-wan	bay
-yama (-san, -zan)	mt. chain
-yu	mineral spring, spa
-zaki (-saki, -misaki)	cape
-zan (-san, -yama)	mt. chain

Figure 21
Glossary from an American Map of Japan

4. A legend explaining the symbols used on the map usually includes all non-standard symbols. (See Figure 22.)

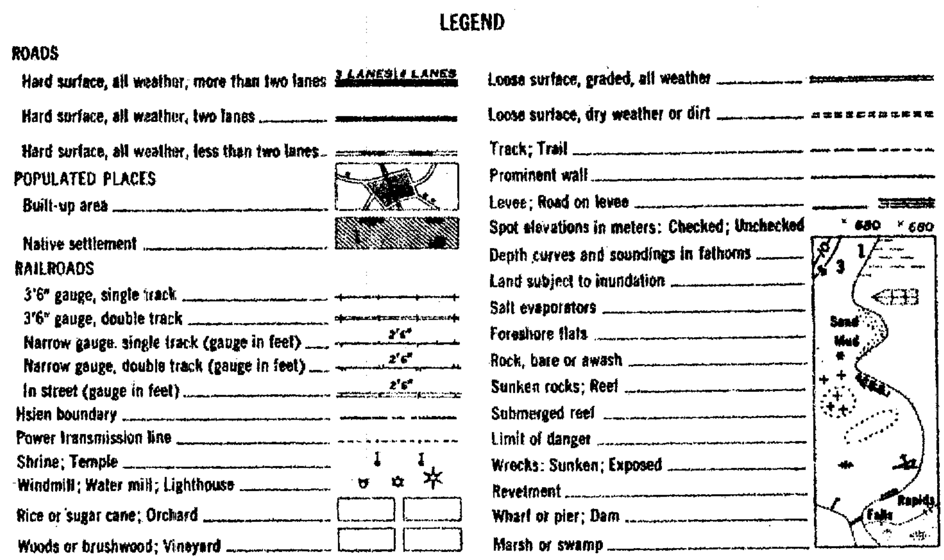


Figure 22.
Symbol Legend

5. The credit note is a combination of references which aid the map reader in evaluating the accuracy of the map and which clarify any unusual conditions for which no explanation exists anywhere else on the map. Information in the credit note usually designates the preparing agency, explains the method and date of preparation, and lists the source materials. This provides information on which to base an evaluation of the dependability of the map. (See Figure 23.)

Prepared under the direction of the Chief of Engineers by the Corps of Engineers, U. S. Army Map Service (AM), Washington, D. C. Redrawn in 1949 from Maryland, 1:25,000, AMS, Sheet 5662 III SE, 1946. Planimetric detail revised by photo-planimetric methods. Contours in Fort Meade Military Reservation Firing Area compiled by photogrammetric (multiplex) methods. Aerial photography Dec. 1947, Jan., April 1948. Original mapping by plane-table and photogrammetric (multiplex) methods by Soil Conservation Service, 1943. Horizontal and vertical control by USC&GS, USGS, CE and Soil Conservation Service. Map field checked. This map complies with the national standard map accuracy requirements.

Figure 23.
Credit Note from an American Map

6. To help the map user identify the military grid and determine grid coordinates, many maps contain a grid reference box in the margin. (See Figure 24.)

GRID ZONE DESIGNATION: 18S	TO GIVE A STANDARD REFERENCE ON THIS SHEET TO NEAREST 100 METERS		
100,000 M. SQUARE IDENTIFICATION	SAMPLE POINT: JOHN WESLEY CHURCH		
UU	1. Locate first VERTICAL grid line to LEFT of point and read LARGE figures labeling the line either in the top or bottom margin, or on the line itself:	70	
	Estimate tenths from grid line to point:	4	
	2. Locate first HORIZONTAL grid line BELOW point and read LARGE figures labeling the line either in the left or right margin, or on the line itself:		12
	Estimate tenths from grid line to point:		4
IGNORE the SMALLER figures of any grid number; these are for finding the full coordinates. Use ONLY the LARGER figures of the grid number; example: 4304000	SAMPLE REFERENCE:	704124	
	If reporting beyond 100,000 meters or if sheet bears an overlapping grid, prefix 100,000 Meter Square Identification, as:	UU704124	
	If reporting beyond 18° in direction, prefix Grid Zone Designation as:	18SUU704124	

TO GIVE A GRID REFERENCE ON THIS SHEET

Use only LARGER Grid figures viz........ 280000

POINT OLIG

LETTER *From face of map* L

EASTINGS.

Take figure of West edge of small square in which point lies 29

Estimate tenths eastwards 8

298

NORTHINGS.

Take figure of South edge of small square in which point lies 00

Estimate tenths northwards 7

007

REFERENCE .... L 29800 ....

Unit.....metre. Square......1000. Reference to nearest.....100.

Nearest similar reference on this grid 500 Km distant

TO GIVE A GRID REFERENCE ON THIS SHEET			
Pay no attention to the smaller coordinate figures at the corners and in margins. They are for finding full coordinates. viz. 56581216			
PAY ATTENTION TO LARGER MARGINAL FIGURES AND TO THOSE PRINTED ON THE FACE OF THE MAP VIZ. 110			
POINT HRAUNTÚN		LETTER	
East *Take west edge of square in which point lies and read the figures printed on this line.*	65	**North** *Take south edge of square in which point lies and read the figures printed on this line.*	21
Estimate tenths eastwards	8	*Estimate tenths northwards*	6
East	658	North	216
REFERENCE 658216			
Unit .... metre Square .... 1,000 Reference to nearest .... 100 Nearest similar reference distant 60 miles			

Figure 24. Grid reference boxes.

7. Names of adjacent sheets may be shown by printing the names around the borders of the map or by an index to sheets diagram in the margin. (See Figure 25.)

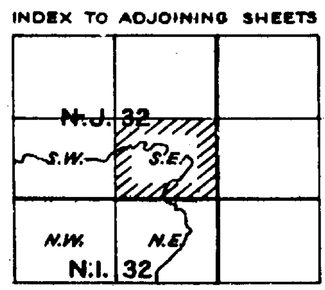


Figure 25.
Index to adjoining sheets from French North Africa Series, 1:500,00, G.S.G.S. 4175

8. Graphic or bar scales appear on all maps and enable the user to measure distances directly on the map in given units of measure (kilometers-meters or miles-yards). The scale is divided into units (kilometers or miles) with a section further divided into smaller units to provide greater accuracy in measuring distances (See Figure 26 and Section II E.)

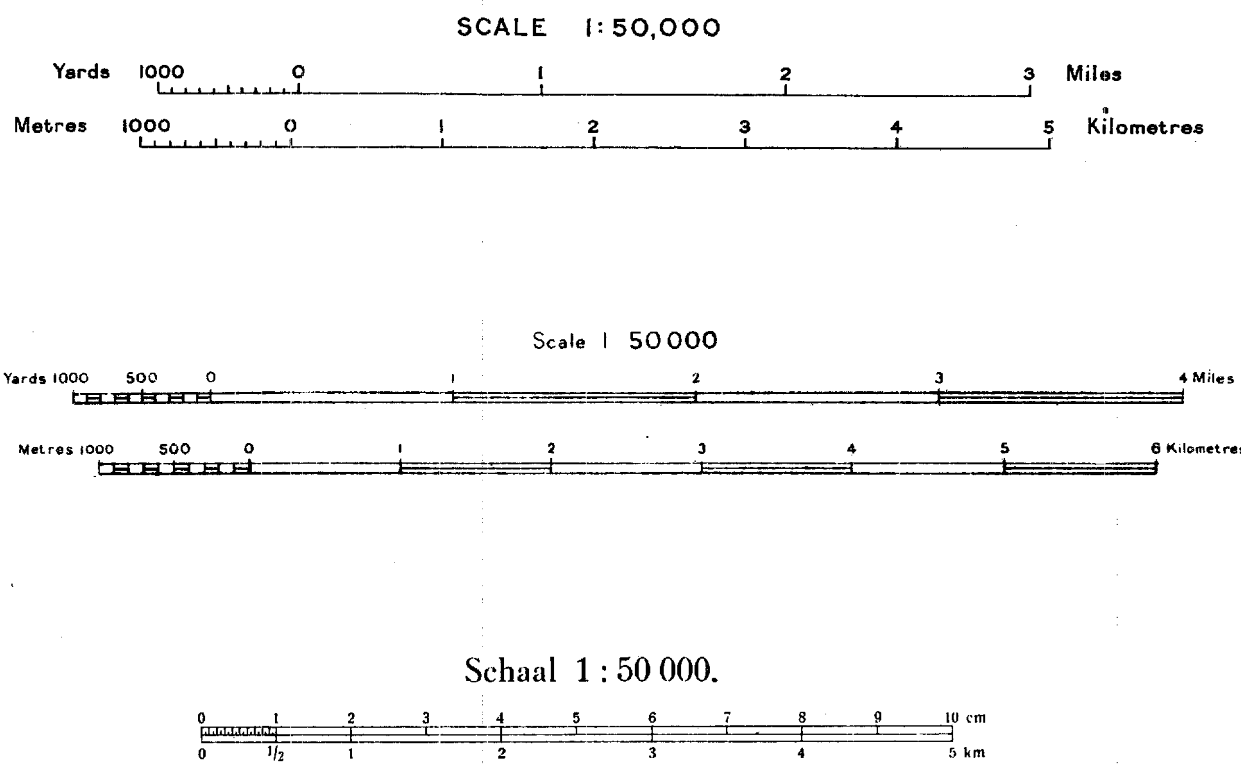


Figure 26.
Three Types of Graphic Scales

9. The map publisher is indicated in the margin either by name or by coded initials. An organization which printed the map may be different from the one which compiled it, and the reputation of the publisher may give an indication of the map's reliability.

10. Several dates may appear on a map: the date of information, compilation date, publishing date, printing date, and revision date. One of these dates will be considered the significant date. Usually it is the date of information or the revision date.

11. Declination diagrams appear in most map margins to show graphically the relationships between magnetic north, grid north, and true north. Different styles may be used but the information is essentially the same. Figure 27 shows several methods of giving declination information.

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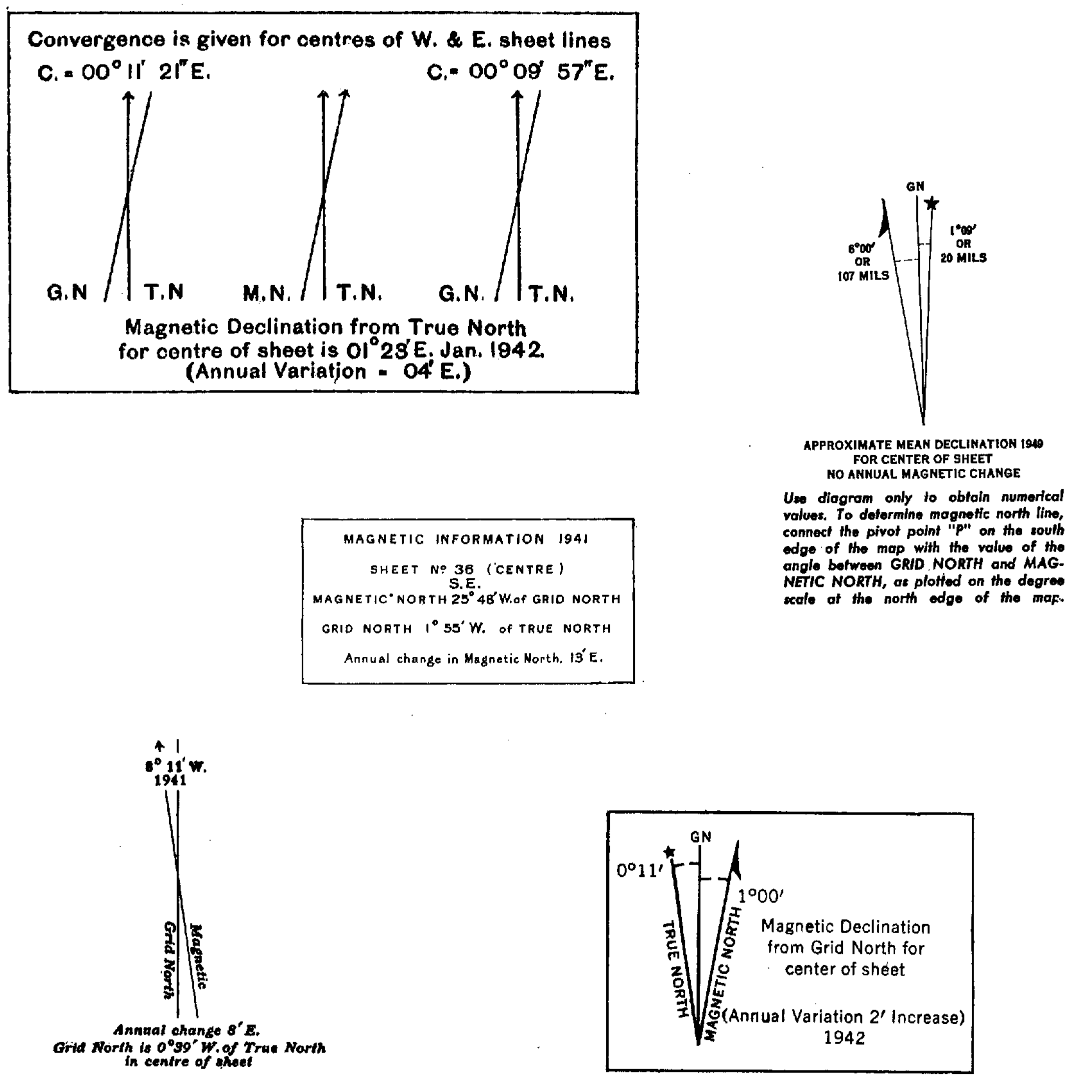
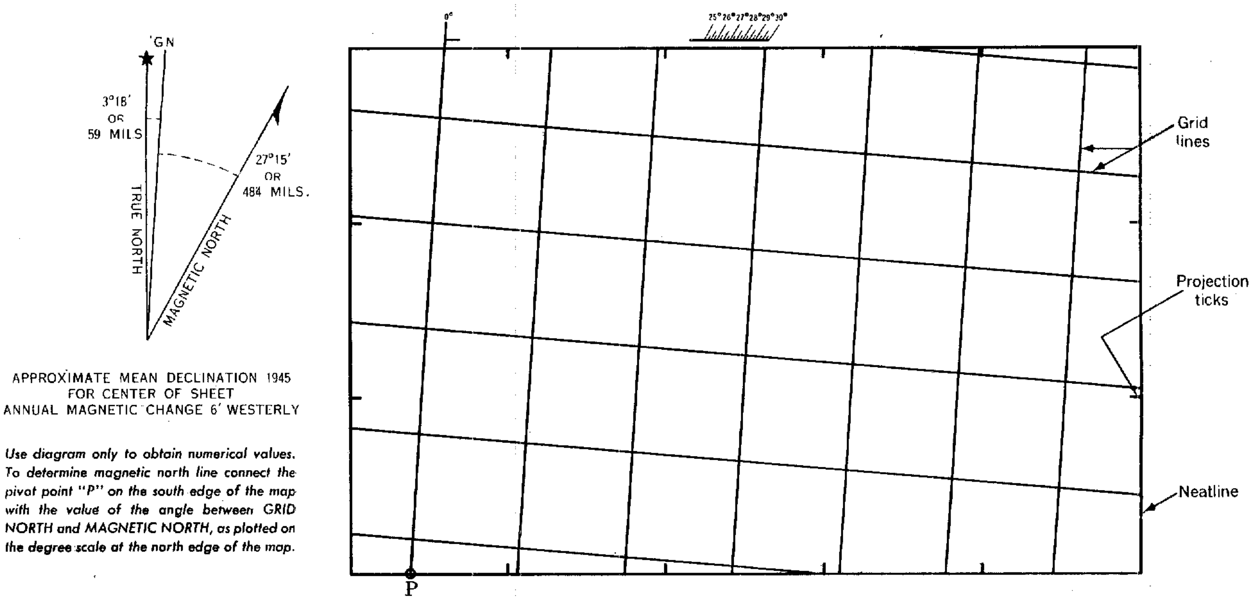
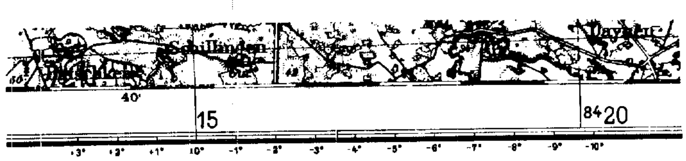


Figure 27.
Declination

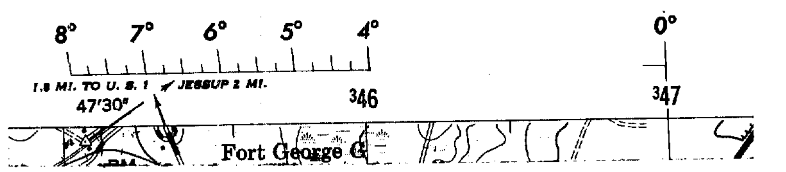
12. Declination protractors often are printed along the border of the map to enable accurate plotting of the current grid-magnetic angle, as determined from the declination diagram. The degree (or grad) scales shown in figure 28. are used in conjunction with the pivot point (P) printed on the opposite border of the map. A line should be drawn from the pivot point to the proper angle shown on the scale.



(1) Declination protractor oriented on a line of the grid from which the magnetic angle is given. Protractor is based on the data shown by the sample declination diagram on the left.



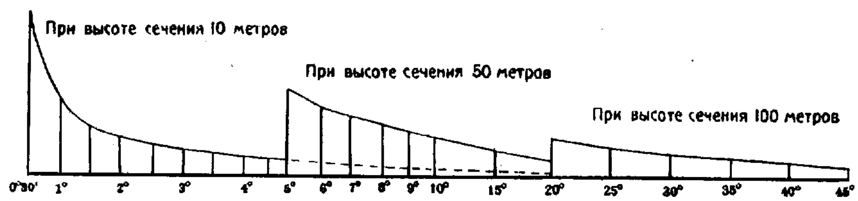
(2) Degree scale of German declination protractor.



(3) Degree scale of United States declination protractor.

Figure 28. Declination protractors.

13. Some topographic maps contain a diagram showing the percentage of slope for various contour intervals. This aids in determining the exact slope of the ground surface as indicated by the contour lines. (See Figure 29.)



Translation. 1. For levels of contour interval 10 meters.
2. For levels of contour interval 50 meters.
3. For levels of contour interval 100 meters.

Figure 29.
Slope Scale from Russian Map at 1:50,000

14. There are often several information notes in the margin, particularly on United States maps, intended to increase the value of the map to the user. These notes may refer to a variety of subjects.

15. Compilation and reliability diagrams show the sources of information used in the preparation of various portions of the map and give an indication of the reliability of each source. These are most often found on maps published by Unted States agencies (See Figure 30.)

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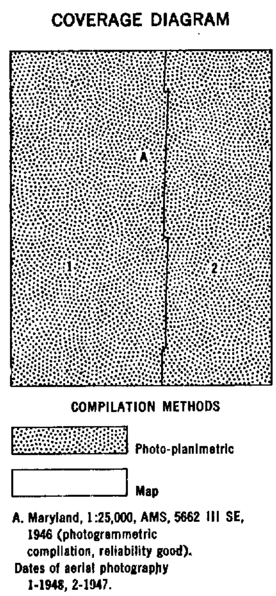

Figure 30.
Compilation Diagram

16. Hypsometric diagrams are used on maps at certain scales to aid in interpreting the relief of the area. These diagrams show the areas of different elevations. (See Figure 31.)

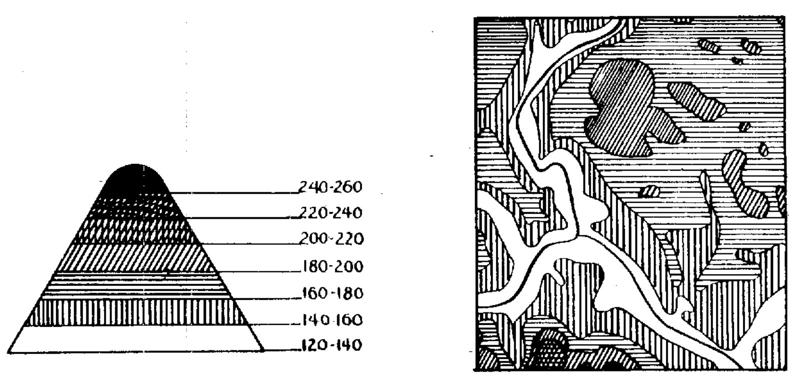

Figure 31.
Hypsometric diagram from Russia series, 1:50,000

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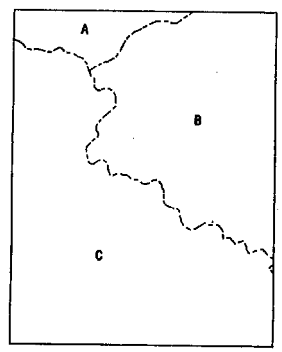
17. To help in locating the political subdivisions of the map area, an index to boundaries sometimes is included in the margin. This is particularly helpful when there are several categories of boundaries on the face of the map. (See Figure 32.)

INDEX TO BOUNDARIES



A. Howard County
B. Anne Arundel County
C. Prince Georges County

Figure 32.
Boundary Index

18. Grid numbers for each grid line usually are located in the margins of the map immediately outside the body of the map. Only the large grid numbers are shown for each line, except at the corners of the map where full grid coordinates are given.

19. If the map contains an indication of the meridians and parallels, their values will be shown around the borders of the map. Sometimes the border consists of a scale giving the subdivisions of the meridian and parallel intervals. There may be a scale for both degrees and grads as shown on the map in Figure 33.

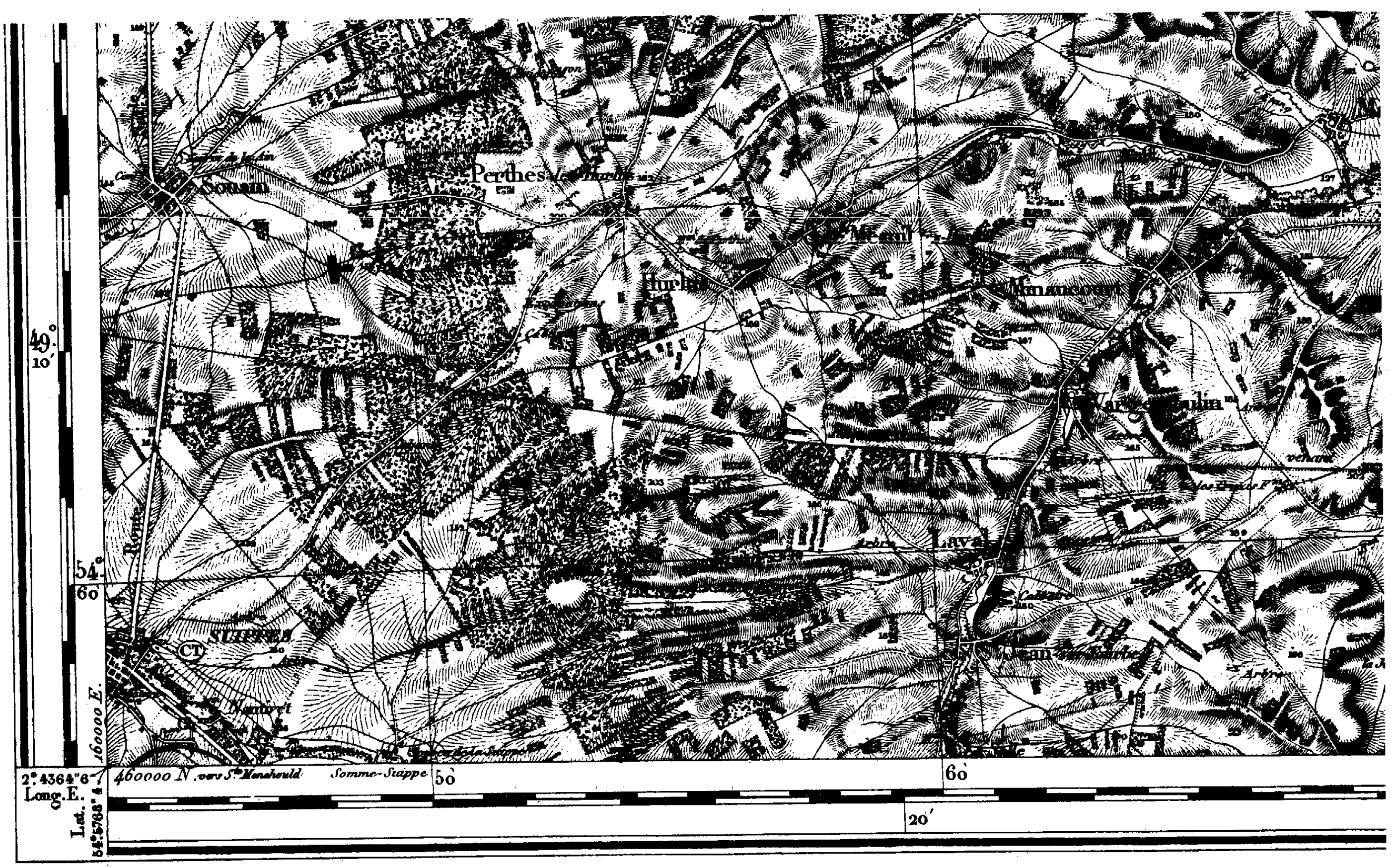
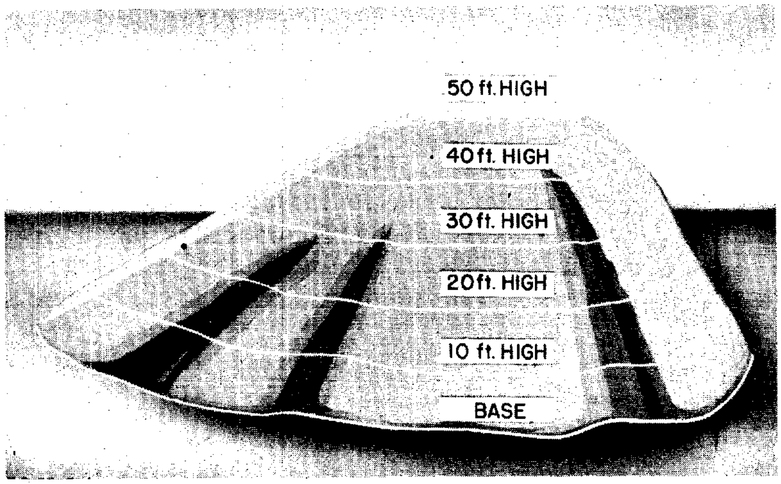


Figure 33. French hachured map, 1:80,000.

C. RELIEF

Since a map is a plane surface, some type of conventional sign must be used in order to represent relief and elevation. On most modern topographic maps, this is accomplished by the use of contours. Relief is the shape of the surface of the earth. By elevation is meant the vertical distance of any specified point on the earth's surface above the reference plane of mean (average) sea level. Some maps use hill and valley shading to indicate the relief. This system assumes the sun is shining on one side of the hills and the opposite side is in shadow. Relief is suggested pictorially so that even an unskilled person can recognize the hills and valleys. Another method of showing relief is the use of hachures, which are short lines drawn parallel to the direction in which the ground slopes at each point. Figure 33 shows a French hachured map at a scale of 1:80,000. Hachures indicate the direction water would flow on the ground surface, and the relative steepness of the slope is shown by increasing the density of the lines on steeper slopes.

1. Contour Lines. Contour lines are the conventional signs drawn on a map to show the different ground forms. After practice the map reader can not only visualize shapes of hills, mountains, and valleys, but can also find elevations of points and determine slope and visibility along given lines. A contour is a line drawn on a map which represents an imaginary line on the ground, all points of which are at the same elevation. For a better understanding of this let us consider the zero contour line to be sea level. If the sea were to rise ten feet the new shore line would be the ten-foot contour line. Similarly, the next higher contour line would be marked for each rise in elevation of ten feet. Figure 34 shows the successive increases in sea level which indicate contours. Figure 35 gives an oblique view of this same hill. From directly above, the hill would appear as in Figure 36. Wiping out the picture of the hill itself, it would appear on a map as in Figure 37 when indicated by contours alone. Contour lines are closer together where the slope is steep, and mountainous areas appear relatively dark on the map. Conversely, in the more gently sloping areas the contours appear relatively farther apart. Where a contour line crosses a stream it must bend upstream in order to remain at its same elevation, and thus will form a pronounced "V" pointing upstream. A small closed contour will indicate the top of a hill. The plane of a contour will always be horizontal and each contour line will be perpendicular to the direction of running water on that surface. Within the limits of the contour interval, the height of every point can be read directly from the map, and the angle of slope can be determined. The elevation of any point that falls on a contour line will



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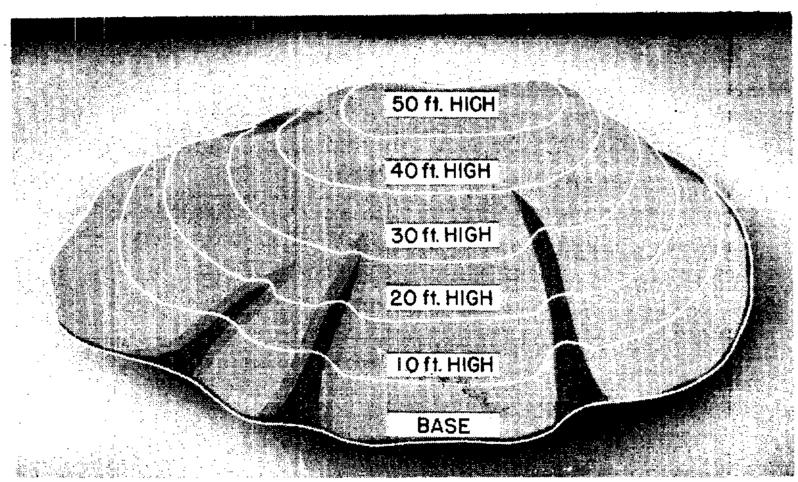

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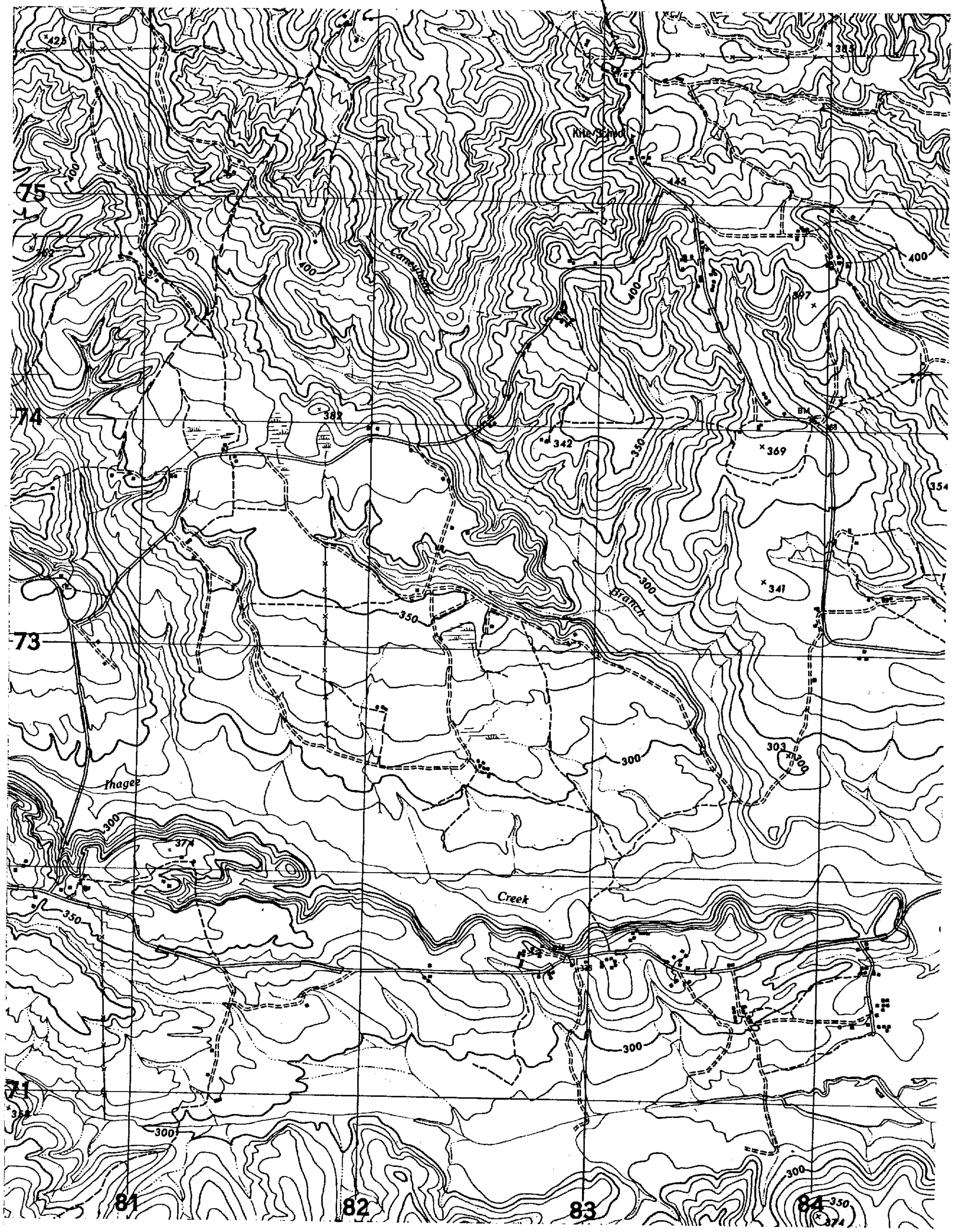


Figure 40. Map, 1:25,000.

2. Profiles. A profile is an exaggerated cross-sectional view of a portion of the earth's surface. Profiles give useful and exact information concerning the type of terrain, slopes, elevation and visibility. If you are unable to visualize the character of the terrain from the vertical view represented by the contours, a profile view will show the shapes of the hills from ground level as we are used to viewing them. To construtt a profile along line A - B in Figure 41, draw a line between the two points.

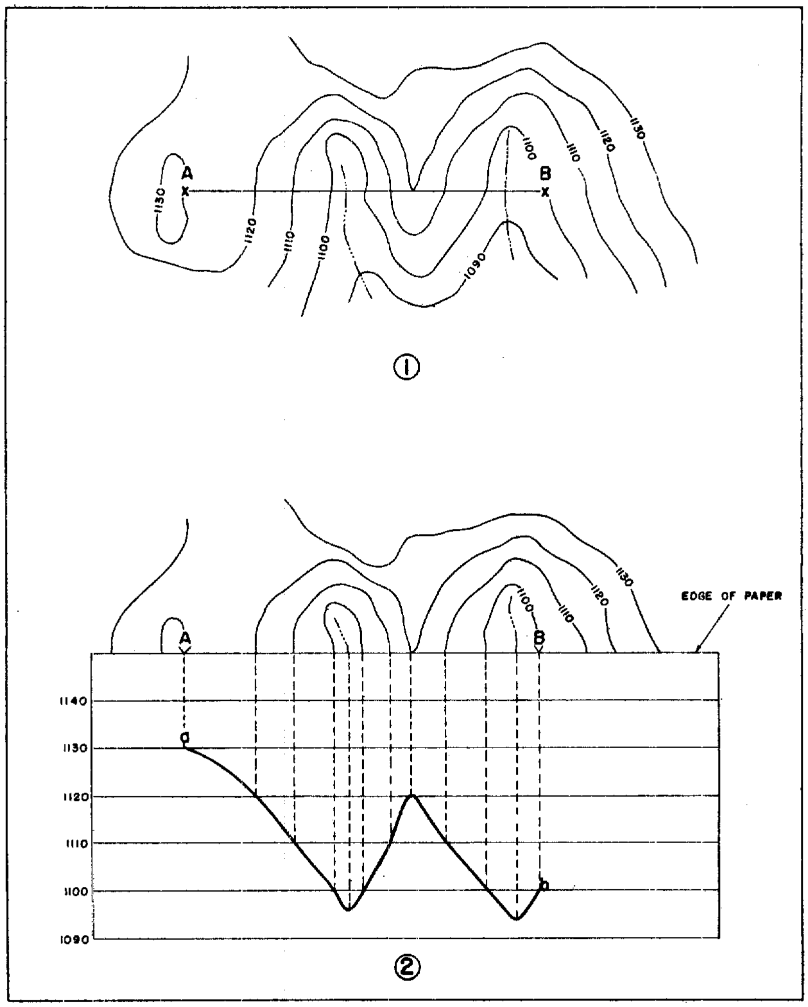


Figure 41.
Construction of a Profile

Then take a piece of ruled paper consisting of equally spaced horizontal lines, each line to represent the elevation of a contour, and the spaces between the lines representing the vertical contour interval. The number of spaces must be sufficient to accommodate the total number of contour intervals between the highest and lowest points involved on the profile. Lines are numbered in sequence, starting at the bottom with the lowest contour number and ending at the top with the highest contour number. This piece of paper is placed over the map with its lines parallel to the profile line A - B previously drawn on the map. From every point on the map where a contour line crosses the profile line, a perpendicular is drawn down and a small tick mark is made on that line on the profile paper corresponding to the contour line on the map. This method maintains the proper horizontal spacing of these points which is essential to the accuracy of the profile. The tick marks are then connected by a smooth curve (line a - b in Figure 41 (2)). Profiles normally show the vertical scale exaggerated in order to emphasize the relief features. They may be drawn to any desired vertical scale by merely changing the distance between the parallel lines on the profile paper. To aid in visualizing the relief as shown by the contours, a hasty profile can be made by plotting only the high points along the profile line.

3. Visibility. One of the important uses of maps for military purposes is to determine whether a point, a route of travel or an area is visible from a given point or position. The extent of the area visible affects selection of targets, siting of weapons, and location of defiladed areas or dead space. Many problems of visibility may be solved by inspecting the map and determining from the contours the ground slope represented. This can be done exactly by constructing a profile. Figure 42 shows the shaded area which is invisible to an observer at point A. These areas are screened from the observer by the mask at point c and by the convex slops between a and c. The extent of defiladed or invisible areas can be accurately determined by constructing several profiles along lines radiating from the observer's position.

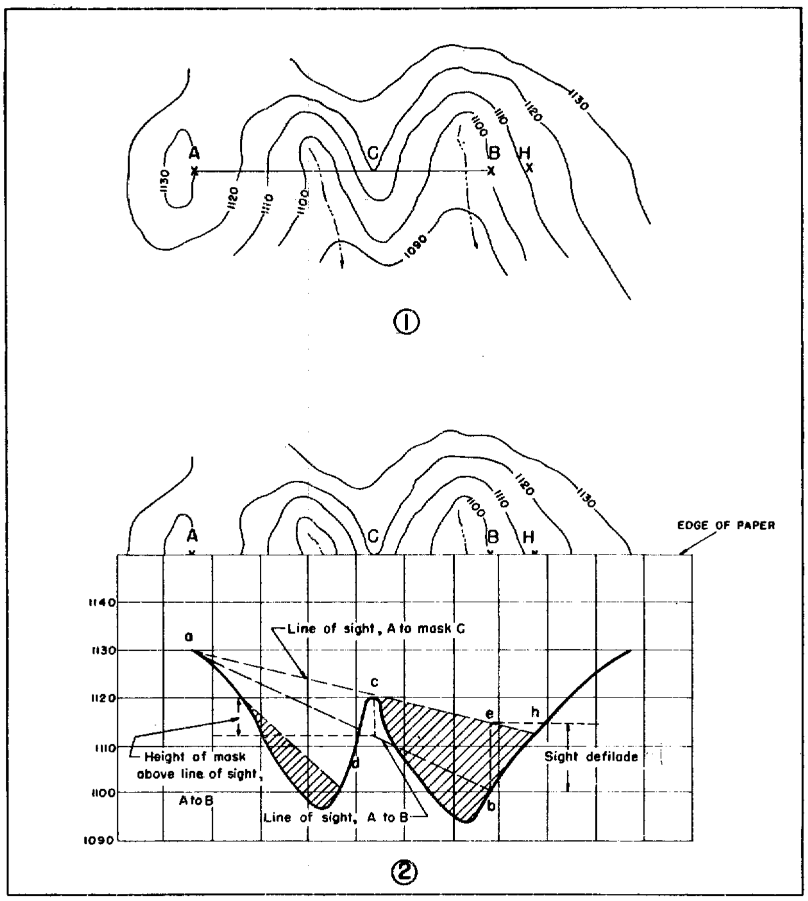


Figure 42.
Determination of Visibility by Profile Method

EXERCISE XIV
Construction and Use of Profiles

Refer to the map in Figure 40 for this exercise.

1. Construct a profile along a line between the road junctions at 820715 and at 822732. Use a vertical scale exaggeration of ten times by drawing the parallel lines on the profile paper four millimeters apart.

2. If a man were standing at each of these two road intersections, would they be able to see each other?

3. Construct a profile along a line between spot height 374 at 812721 and spot height 342 located at 828739, with a vertical scale exaggeration of 20 times.

4. Are any points along this profile line not visible from spot height 374?

5. Are any points along this profile line not visible from spot height 342?

6. From which end of the profile line is the most terrain along the line visible?

7. Is any point along the line not visible from either end?

D. MAP ORIENTATION

1. A map is oriented when, in a horizontal position, its north side is toward the north and all lines of the map are parallel to the corresponding lines on the ground. A map reader is oriented when he knows his position on an oriented map and the cardinal directions on the ground. A map will be of small use in the field unless its possessor can orient himself readily. It follows that command of the simpler methods of practical orientation is of prime importance to the map reader.

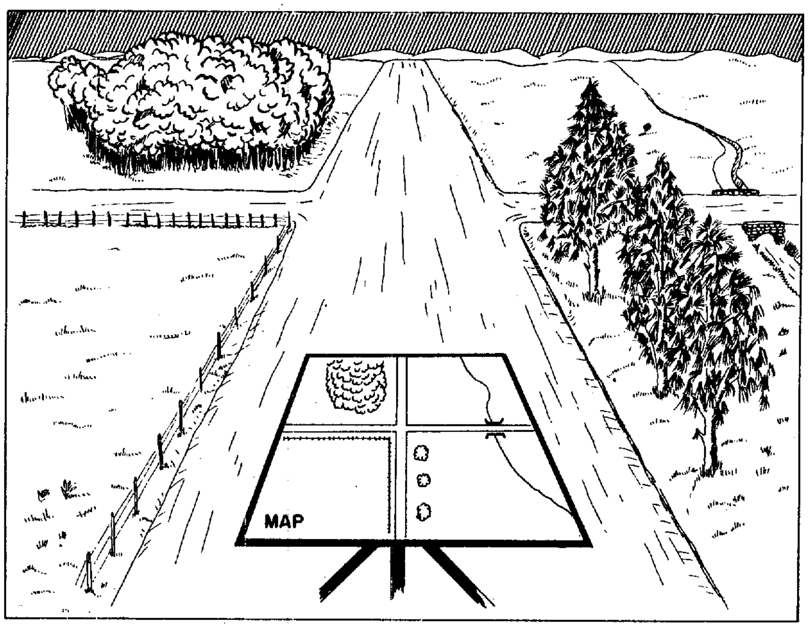


Figure 43.
Orienting Map by Inspection

2. Approximate orientation of a map can be done by inspection. Figure 43 shows how a map may be oriented by carefully observing the road system and features in the immediate vicinity. The map has been rotated horizontally until the road on the map parallels the road on the ground. Care must be used to see that positions of nearby ground features are in similar relation to their corresponding conventional signs as shown on the map. Any group of features identifiable both on the map and on the ground can be used for orientation. If you can identify your position on the map and can see some distant ground feature also on the map, the map can be oriented by sighting along the surface of the map from your position to the distant feature, turning the map until the symbol for the feature falls on your line of sight. (See Figure 44.) This is the most practical method for ordinary purposes and may be used as a rough check on more accurate methods.

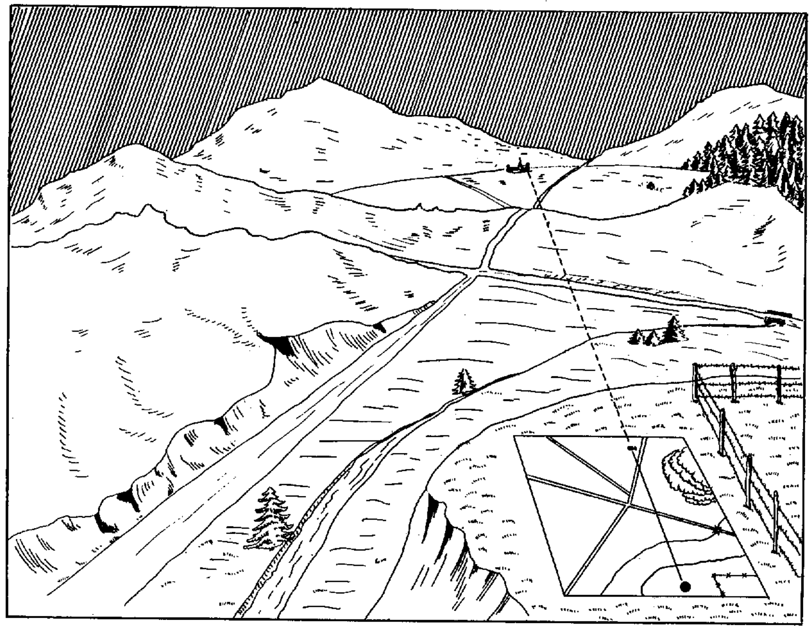


Figure 44.
Orienting Map by Means of Distant Point

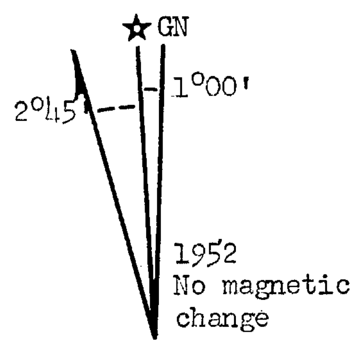
3. The most accurate method of orienting a map is by use of a compass. Orientatinn is along the magnetic north line. Determine the magnetic declination for the current year by referring to the declination diagram. Somewhere on the map draw a straight line whose north end points toward magnetic north. This can be done by measuring with a protractor the proper grid-magnetic angle from a grid line, or the angle for magnetic declination measured from a meridian. Then place the front and rear sights of the compass along the magnetic north line with the front sight toward the north, and turn the map and compass together until the north pointer of the compass falls under the fixed index mark. If your map contains a protractor scale (See Figure 28), draw a straight line from the pivot (P) to the correct degree (or grad) mark on the scale for magnetic declination of the present year. This line will be the magnetic north line.

EXERCISE XV
Map Orientation with and without a Compass

1. Using the protractor scale and declination diagram shown in Figure 28 (1), describe in detail how you could orient your map with a compass.

2. If you are located at 833756 on the map, Figure 40, and do not have a compass, how would you orient your map?

3. If your map, Figure 40, did not have a protractor scale but you had a protractor (Figure A-I), and the map contained this declination diagram:



how would you draw the magnetic north line for orienting your map with a compass?

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4. Determining Directions with a Watch. A watch set on local standard time can be used to determine direction. In the north temperate zone (from 23½ degrees to 67½ degrees), point the hour hand at the sun. South is halfway between the hour hand and 12. Directly opposite from south is north. In the south temperate zone, point 12 on the watch toward the sun. North is halfway between 12 and the hour hand. (See Figure 45.) This system usually will not work in the tropics. Reading directions from a watch can be accurate to within eight degrees.

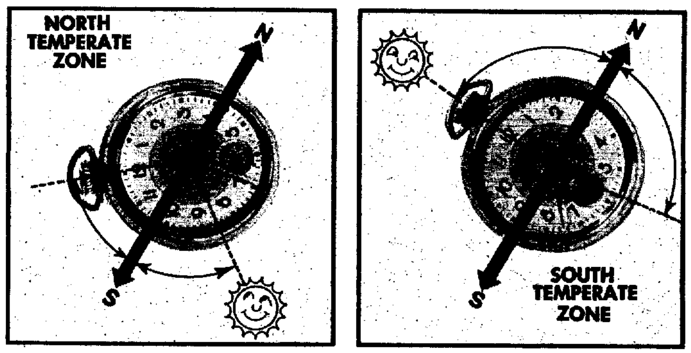

Figure 45.
Using Watch as Compass Substitute

5. Finding North from the Stars. In the northern hemisphere, the north direction can be determined by locating the north star (or pole star). The north star is approximately over the north pole of the earth. It is the brightest star in its immediate vicinity and is about halfway between the big dipper and the cluster of bright stars resembling a big M or W. The two stars in the big dipper opposite the handle point toward the north star which is at a distance about five times the distance between the pointer stars. (See Figure 46.)

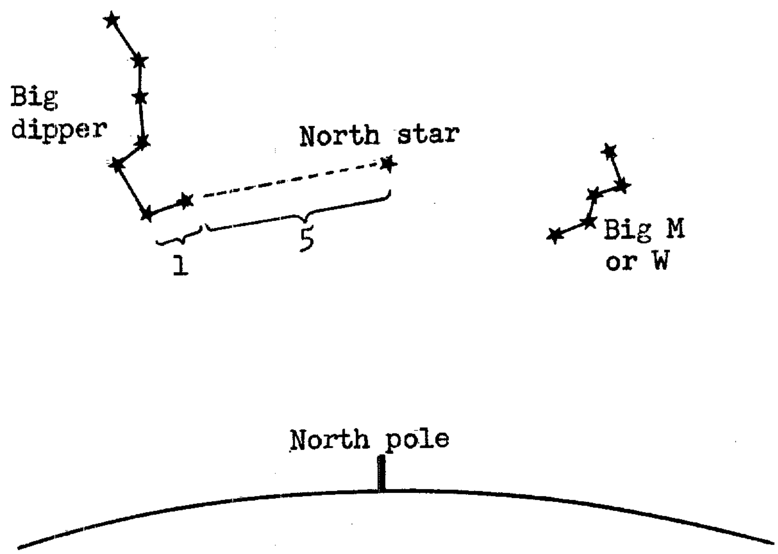

Figure 46.
Finding North from the Stars

6. Finding South from the Stars. There is no bright star directly over the south pole, but in the southern hemisphere four bright stars form the Southern Cross, which can be used as a guide. The Southern Cross also resembles the shape of a kite with the long axis pointing toward a point in the sky directly over the south pole. This point in the sky over the pole is at a distance 4½ times the long axis of the Cross. (See Figure 47.)

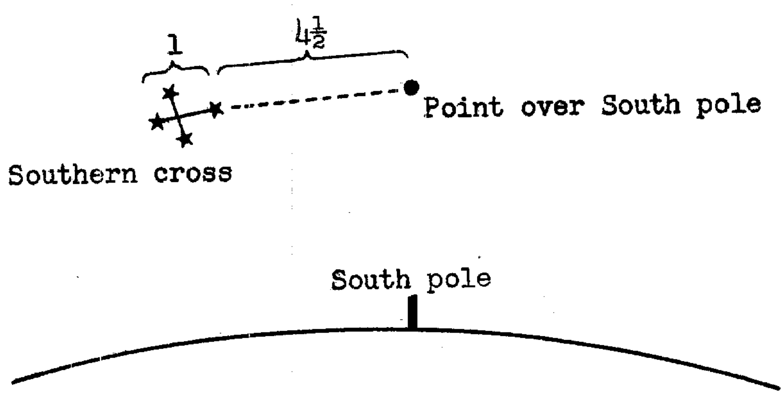

Figure 47.
Finding South from the Stars

E. SCALE

In map reading, the scale of the map is a first consideration. The scale is the relation between measurements on the map and actual distances on the ground. The scale of a map is expressed in one or more ways.

1. Actual equivalents given in words and figures, as one inch to a mile, means that one inch on the map equals one mile on the ground; quarter-inch scale means that one-fourth inch on the map equals one mile on the ground. This is a common method for expressing scale on British maps.

2. The scale of a map may be shown as a representative fraction (RF). This fraction expresses the ratio between a given distance on a map and the corresponding distance on the ground. The RF is written either as a ratio (1:25,000) or as a fraction (1/25,000), which means that one unit of distance on the map equals 25,000 such units of distance on the ground. The same kind of units of distance measured from the map must be applied to distances on the ground. Any unit can be used, including millimeter, centimeter, inch or foot. The greater the denominator of the fraction, the smaller the scale--a 1:25,000 map is a large-scale map, and a 1:1,000,000 map is a small-scale map.

3. The graphic scale or bar scale is a means of expressing visually or graphically the scale of the map. It is divided into parts, each division being marked not with its actual length but with the distance each length represents on the ground. Usually there will be one part graduated into kilometer (or mile) units and fractions of them; this is known as the primary scale. The other part is graduated in meters (or yards) for more exact measurements, and is called the extension scale. Many maps show both the kilometer and mile scales. (See Figure 26.)

a. To find the distance between two points on a map, lay the straight edge of a piece of paper or other material along a line between the two points, mark their location on the straight edge by using short straight marks called "ticks" at right angles to the edge of the paper. Take the marked straight edge and place it below the graphic scale in the margin of the map to determine the ground distance required. Where the distance is greater than the length of the graphic scale, apply the primary scale one or more times until the remainder can be measured on the extension scale. Figure 48 illustrates this method of measurement and shows the houses at A and B to be 1,000 yards apart.

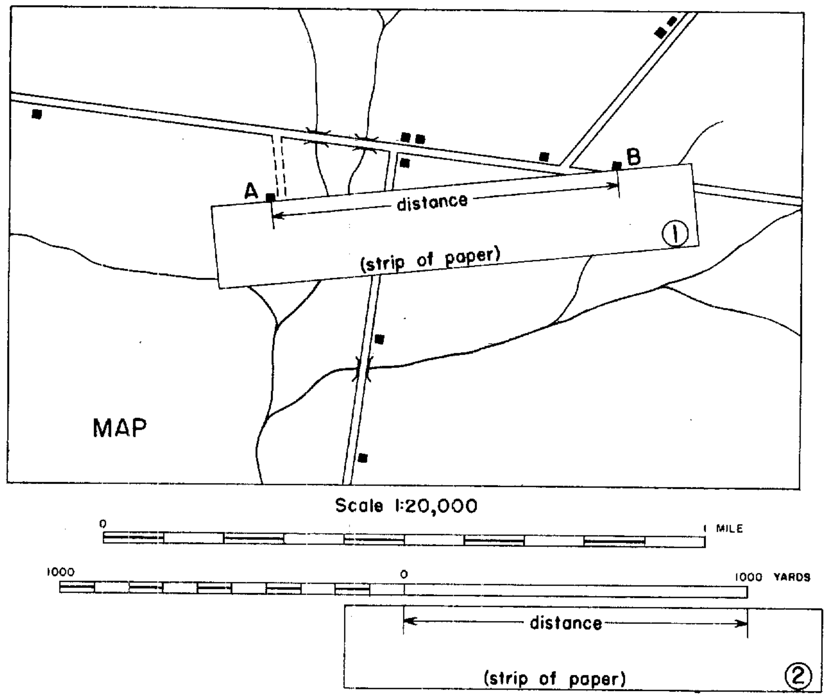

Figure 48.
Using Graphic Scale to Measure Distance

b. To find the distance along an irregular or curved line on the map, divide the line into shorter segments, each of which is approximately straight. Take a straight edged piece of paper, lay it along the first segment of the line and make a tick mark across the map and paper. At every curve in the line, make another tick mark, turn the paper so the edge again lies along the segment in question, and register the last tick marks. Continue this until the distance is completely measured. The final position of the paper strip is illustrated in Figure 49. The paper strip is then applied to the graphic scale as in Figure 48, and the ground distance is read.

EXERCISE XVI
Map Scale

1. Using one of the graphic scales in Figure 26, measure the distance along the road on the map, Figure 2, between points 5 and 6.

2. What is the total length of the railroad shown on this map?

3. What is the straight-line distance between the railroad station at point 4, and point 3?

4. Suppose you have 12 maps at 1:50,000 which provide complete coverage for your area of operations. How many map sheets of approximately the same size would it require to depict this area at 1:25,000?

5. If you are planning routes in and out of an area covering approximately 400 square kilometers, would the best maps to use be at the scale of 1:25,000, 1:50,000, 1:250,000 or 1:1,000,000?

6. To determine the greatest amount of detail about an area, would you consult maps at the scale of 1:1,000,000, 1:250,000, 1:50,000, or 1:25,000?

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F. MAP IDENTIFICATION

1. A map user must constantly refer in some manner to specific maps. The map title is not an adequate identification of a particular map, since often there are several maps at different scales with the same title. An individual map must be clearly and accurately identified when you order it or refer another person to it. When citing geographic or military grid coordinates, it is desirable to identify the map from which they are taken as a double check on accuracy. When reporting information obtained from a map, the accuracy of that information is suggested by indicating the map used, and especially its scale. If a partial tracing or overlay is made from a map, inclusion of proper map identification gives due credit to the source, to which another person can refer for further details.

2. Several kinds of information are necessary in order to identify a map properly.

a. Title or Sheet Number. If a map has a sheet number, that usually is more significant than the title.

b. Series Name or Number. Identification of a map that is part of a series must always contain the name of the series and/or the series number.

c. Scale. The map scale must always be given.

d. Other Information. In certain instances the date of the map should be given. For example, when tracing a part of a map on an overlay, the date or edition should be indicated so that any changes of map detail on subsequent editions can be understood by the overlay user. Additional helpful information might be the nationality of the map publisher. It is best to assume the other person has no knowledge of the map or your specific project, and to give complete map identification.

III. MAP SUBSTITUTES

A. DEFINITION

A map and a map substitute are very similar, although not identical. Each depicts a portion of the earth's surface, as a line drawing or pictorially. The map substitute may not be to an exact scale, but it does have a scale. Many of the properties of a map are incorporated into map substitutes, and an item used as a map supplement must have certain necessary map characteristics which justify its use with a map. Although the term map substitute implies that it is used only when a map is not available, such is not the case. It can be used instead of a map, as a map substitute, or along with a map, as a map supplement.

Two types of map substitutes are map overlays or tracings, and sketch maps. Overlays combine a selective use of map data and additional information that corrects, completes, or brings up to date data appearing on the map. Information included on the overlay can serve purposes of emphasis or reporting. For example, an overlay may include only the railroad facilities of an area as traced from a map; or the overlay may show only the new railroad facilities constructed since the map was published. In the first instance the overlay would serve as a map substitute or an incomplete map. In the second case the overlay would supplement the map and bring it up to date with respect to the railroad information. Sketch maps are hand-drawn representations of certain features, usually from a different perspective. While maps show ground features as seen from above, sketches represent ground features as seen from ground observation points.

B. MAP OVERLAYS

1. An overlay is a transparent or semi-transparent sheet giving special map information. When the overlay is laid over the map on which it is based, its details supplement or emphasize certain features of the map. An overlay is a graphic method of explaining a situation which might otherwise require many pages of writing. An overlay may be a tracing of selected portions of the map from which it is copied, it may consist only of additional details not on the map, or it may be a combination of both kinds of data. The overlay need not cover the entire map, but may cover any portion of the map desired.

2. When insufficient quantities of a particular map are available for an operation, an overlay containing the pertinent map data often will suffice. If there is access to a map only for a limited time, the information of interest can be traced on an overlay for future reference. A map

can be simplified and made easier to read by preparing an overlay containing only the necessary details for an operation. To revise a map and bring its information up to date, it is best to make all additions and corrections on an overlay so as not to add to the congestion of the map. An overlay is valuable for reporting information which is not on the map, or in specifically identifying certain map data. The physical relationship between the data being reported on and nearby features appearing on the map can be made clear. It is a simple matter to add explanatory notes to the overlay, whereas the map may not have sufficient blank spaces for notes.

3. To construct an overlay, place the overlay material on the map to cover the area to be traced. Fasten the overlay paper securely to the map along one side so that the two sheets will not move in relation to each other. Leaving one side free will allow lifting the overlay to inspect the map more closely while making the tracing. Next draw register marks on the overlay paper to enable future orientation of the overlay with the map. These register marks should consist of small cross marks traced over the intersection of vertical and horizontal grid lines, or other similar lines. There must be at least two such register marks located near opposite corners of the overlay, and it is preferable to have four register marks, one near each corner. The register mark must include the numbers of the grid lines or other exact identification of the features represented. Before drawing any detail on the overlay, record the correct identification of the map (see II F) so that another person would have no difficulty knowing the map to which the overlay applies. This identification is placed in the margin of the overlay and includes the map title or sheet number, map series name or number, scale of the map, the edition number or date of the map if appropriate, and date of the overlay. Only after the above is completed should detail be traced or drawn on the overlay.

4. The amount of information included on an overlay should be the least amount that will accomplish the desired purpose. Too much detail clutters the overlay and tends to destroy its value. However, all pertinent data should be included to provide adequate orientation for any new details added and to make the overlay understandable without always placing it over the map. Figure 51 illustrates an overlay.

* * * *

EXERCISE XVII
Overlays

Construct an overlay of the map in Figure 4, indicating proper map identification, register ticks, and showing areas of forest and the major drainage lines. Refer to the legend in Figure 20 for identification of the symbols.

[redacted]

STATINTL

42

10 July 1957

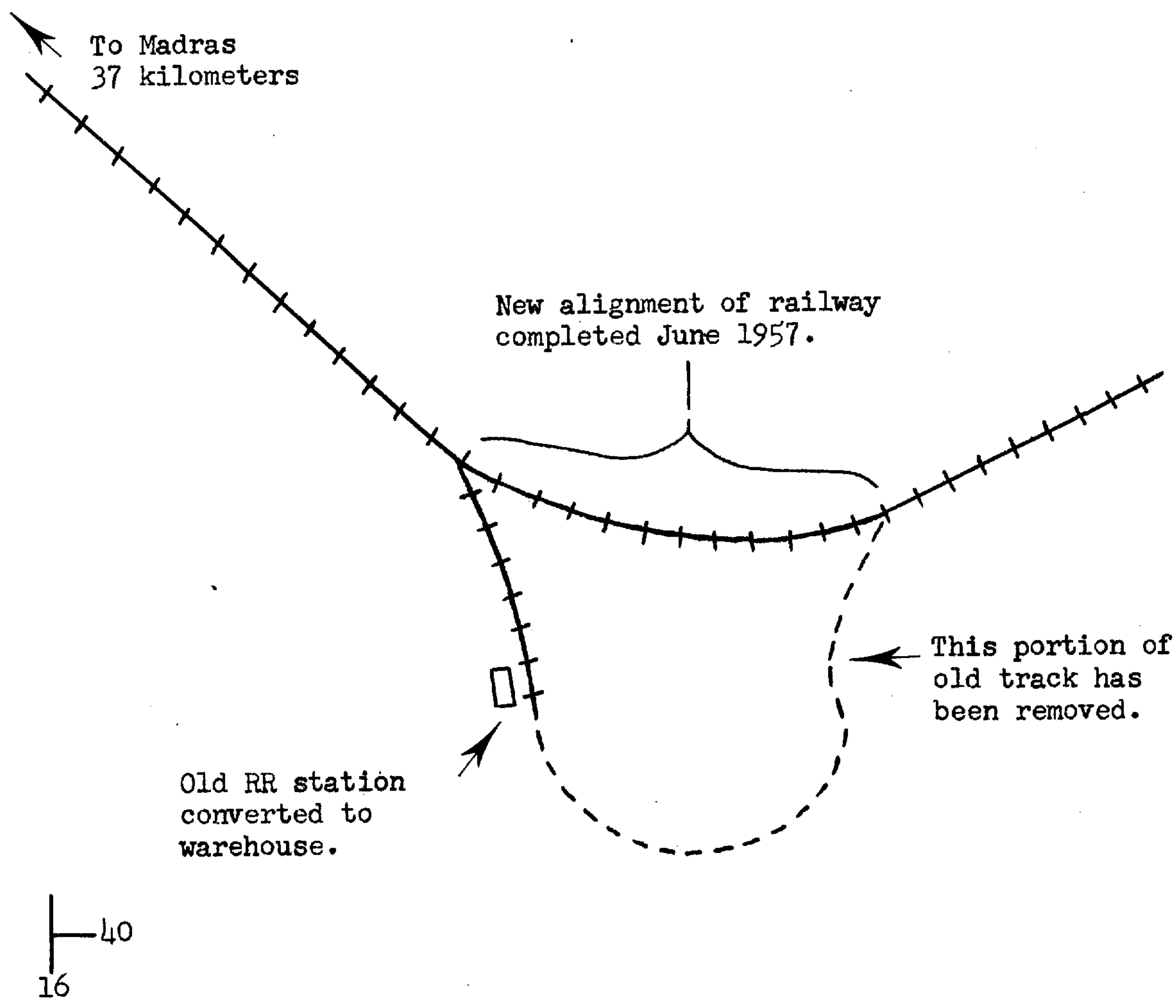

Figure 51.

A typical map overlay for reporting information.

C. SKETCHING

1. The military sketch or hasty sketch map will not be discussed in detail because usually it requires specially trained map-making personnel and special materials such as aerial photographs and surveying equipment. It is the term applied to military maps made in the field by military units under emergency conditions when no adequate maps exist. A panoramic sketch is a pictorial representation of terrain as seen from one point of observation. This observation point is on the ground and shows the area

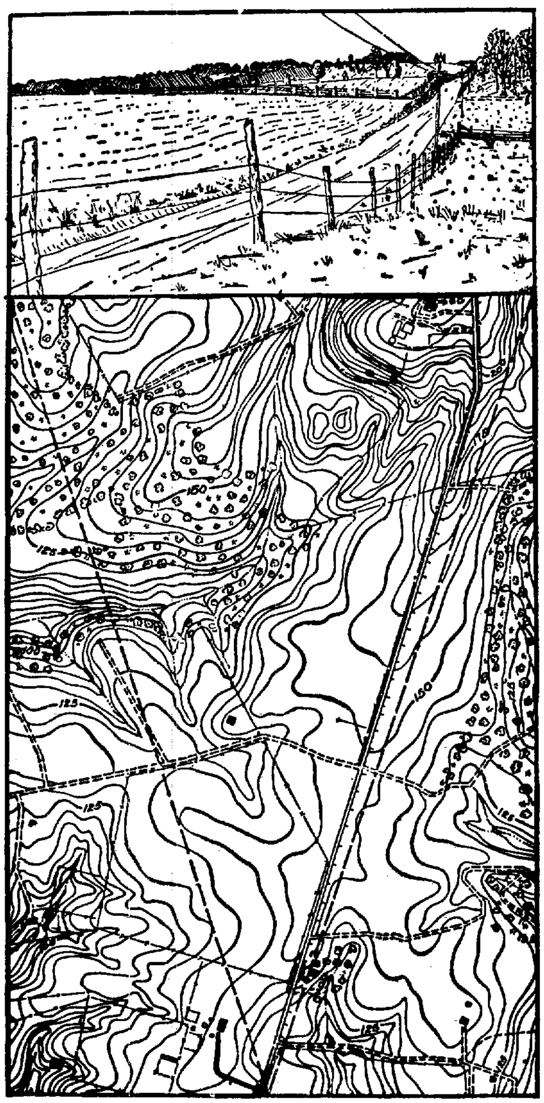

Figure 52.
Comparison of Panoramic and Military Sketches

in the manner in which we are accustomed to viewing it. It includes the horizon and intervening features such as topographic crests, roads, houses, woods, and fences. Its great value lies in the rapidity with which it can be made and read. A trained panoramic sketcher can prepare in a few minutes a sketch which conveys information of value requiring little time or training to interpret. A comparison of the manner in which the same piece of terrain is depicted by a panoramic sketch and by a topographic map is shown in Figure 52.

2. The principles of a panoramic sketch apply both to distant views and to nearby objects which are sketched. These are the principles of perspective drawing. The horizon line is the line formed by the intersection with the ground of a horizontal plane at the height of the sketcher's eye. In level country and over water, the horizon line is coincident with the sky line. In rolling country the horizon line usually is a little below the lowest point in the sky line. Lines which are actually parallel on the ground appear to converge as they recede from the viewer and appear to meet or vanish at a point called the vanishing point of that system of parallel lines. The correct effects of distance, direction, and slopes which are commonly attributed to the artist's inspiration are in reality at the command of anyone who will apply the following rules:

a. Parallel lines, which on the ground are horizontal, converge and vanish at a point on the horizon. (See Figure 53.)

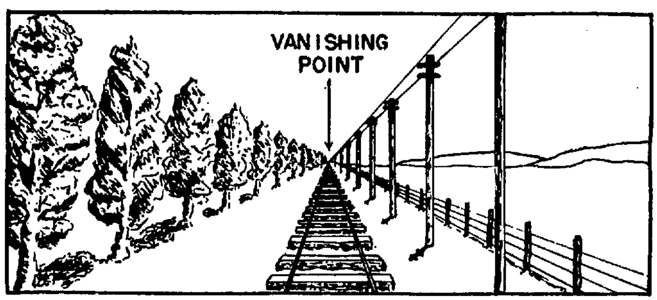

Figure 53.
Vanishing Point

b. Parallel lines which on the ground slope downward away from the observer, vanish at a point below the horizon. (See Figure 54 (1).)

c. Parallel lines which on the ground slope upward away from the observer, vanish at a point above the horizon. (See Figure 54 (2).)

d. Parallel lines receding to the right vanish to the right; those receding to the left vanish to the left. (See Figure 54 (3).)

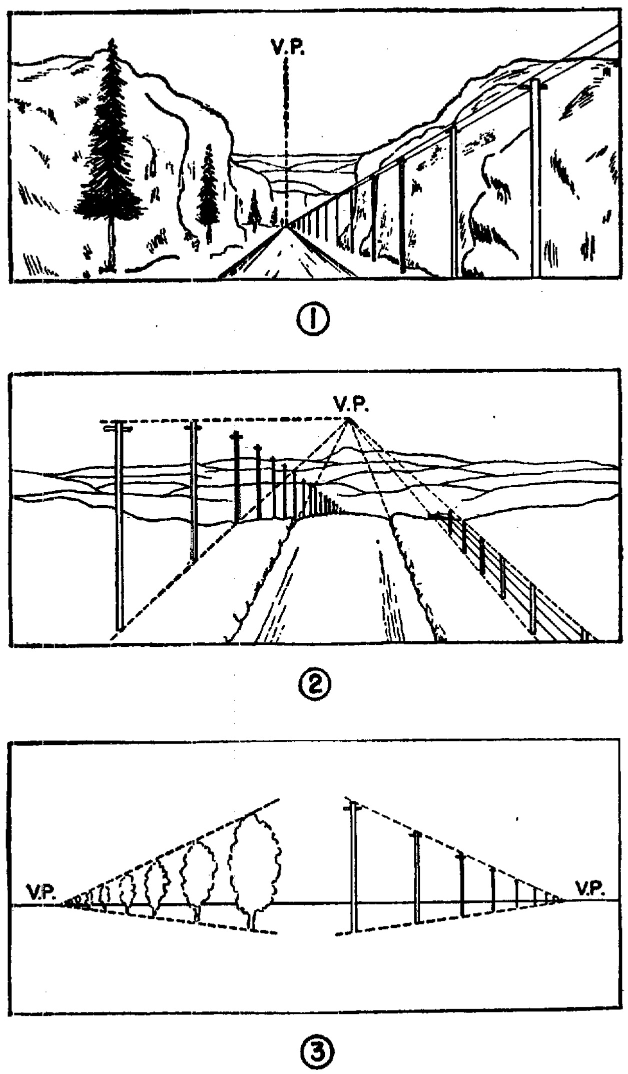

Figure 54.
Various Types of Vanishing Points

e. Parallel lines nearly parallel to the observer's line of sight appear to converge very rapidly while those at right angles to the line of sight appear to remain parallel. Vertical lines on the terrain remain vertical in perspective.

f. The apparent size of any object decreases in proportion to its increased distance from the observer.

g. The apparent distances between regularly spaced objects decrease in proportion to their increased distances from the observer. (See Figure 55 (2) E.)

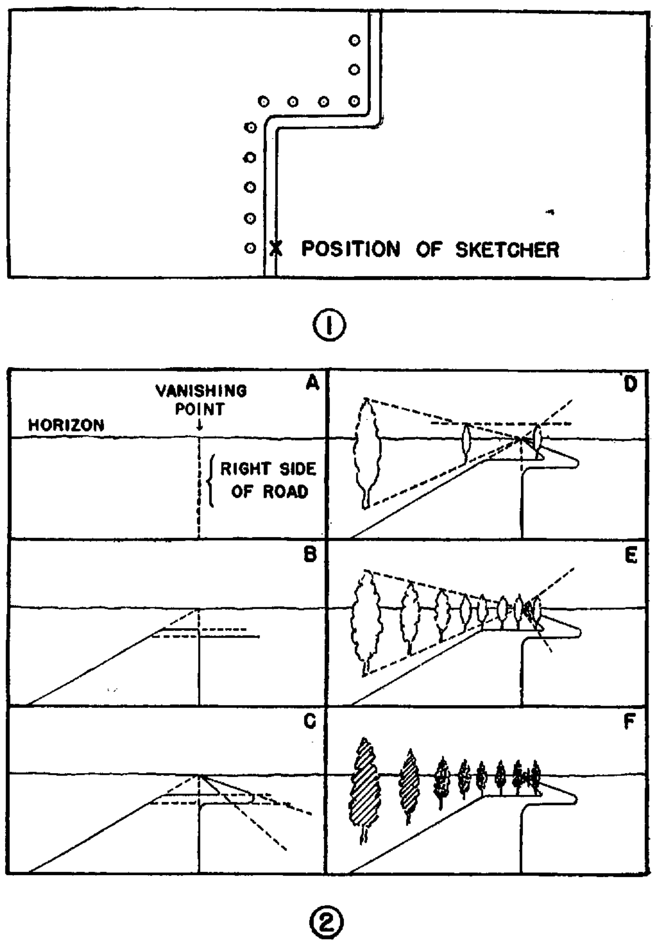

Figure 55.
Steps in Preparing a Panoramic Sketch of a Road

3. The successive steps in the perspective drawing of a section of flat terrain containing a road lined with trees approximately the same height, are shown in Figure 55 (2). The sketcher is facing north. By rule a, the road stretches extending north will have a common vanishing point in the horizon; and by rule e the sides of the road extending north will converge very rapidly. Also by rule e, the sides of the road extending east remain parallel in perspective and the trees remain vertical. The relative sizes of the trees and the relative distances between them are governed by rules f and g.

4. Delineation is the portrayal of objects or features of the landscape as they appear to the observer. Absolute simplicity is essential in a panoramic sketch. No line should be drawn without a definite idea as to what it is to represent and as to the necessity therefor. The sky line, topographic crests, and roads are the main control lines of

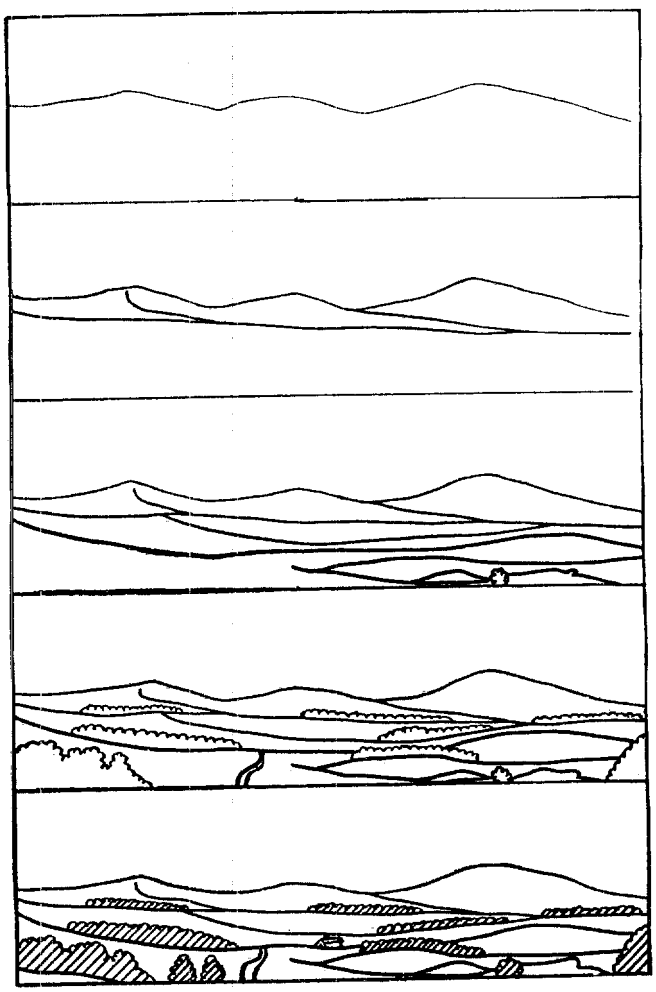

Figure 56.
Delineation showing the order in which a sketch is built up.

the sketch and should be drawn in first to form a framework on which the details are properly placed. Figure 56 shows how features should be represented with a few, rather than many lines. Preferably a conventional outline should be employed. This increases both speed and clearness and leaves room for the addition of important details without overcrowding the sketch. The effect of distance may be increased by making the lines in the foreground heavy and distant hills very light. Full lines are better than broken ones. Important details in the distance may be drawn heavily or enlarged for emphasis. A light crosshatch or shading may be employed to distinguish wooded areas from open fields when necessary. When consecutive tree groups are partially superimposed, alternate groups should be shaded. Crosshatching should follow the natural lines of an object, such as the courses of masonry in a wall. Any attempt to include artistic values in the sketch usually will prove detrimental.

5. In making a panoramic sketch, follow these steps in order:

a. Preliminary study of the terrain. - Before commencing a sketch, the observer should carefully study the landscape so that he may distinguish the various topographic crest lines in their proper relation to each other and to the larger features of the terrain. If a map is available, it should be studied in conjunction with the terrain.

b. Adoption of a scale. - A suitable scale for panoramic sketches is two centimeters on the sketch equals three degrees. This scale should be used for both horizontal and vertical measurements.

c. Selection of reference point and reference line. - Select a conspicuous and permanent reference point in the sector to be sketched, preferably one not closer than 500 meters. Draw a vertical line across the sketch sheet, so positioned that it will pass through the reference point in the finished sketch. This line then becomes the reference line for all horizontal measurements in the sketch.

d. Addition of marginal data. - An exact description of the point from which the sketch is made must be included in the margin. Also include an indication of the scale, the date and time, and a magnetic north arrow.

e. Horizontal and vertical control. - Horizontal control is obtained by measuring the deflection right or left of the vertical reference line to prominent features that will appear on the sketch. Consistent measurements to scale can be made by holding the sketch pad vertically in front of your eyes so that you can just see the desired feature over the top. For the scale 2 centimeters to 3 degrees, it should be held exactly 38 centimeters from your eyes. Then, sighting across the edge of the pad, you will find that all major features appear at scale distance from the reference line. These features can then be transferred to their proper locations on the sketch.

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To help determine the correct distance to hold the pad from your eyes, you can prepare a string with knots at the correct distance and hold one end between your teeth, or cut a stick that length and rest one end of it on your chin. For vertical control it is best to use the sky line or some horizontal crest as a reference line from which distances to objects are measured and transferred to the sketch. It is necessary that this line be drawn in first and as accurately as possible. It is best to prepare a measuring stick at the scale of the sketch by marking several five-millimeter intervals on a short stick that can be held 38 centimeters from your eyes by the string or measured stick. When using this scale it is not necessary to hold up the sketch pad. As skill increases it will be found necessary to measure the deflections to relatively few points, the others being interpolated by eye. Sketch in lightly the sky line, crests, roads, and any other main outlines to form the framework of the sketch. Then compare these lines carefully with the terrain before adding details.

f. Addition of details. - Details should not be added simply to fill up space or improve the appearance of the sketch. The amount of detail will depend largely upon the purpose for which the sketch is made. Select those details that will increase the value of the sketch. Label those features on the sketch which require it for clarity.

6. When sketching nearby objects to which you have access, actual measurements should be made if possible. Show several views of the object if that is necessary to make clear its significant features. Apply the principles of perspective to the drawing and include only those details which add to the value of the sketch. Label all significant dimensions. If it is not possible to make direct measurements, dimensions can be accurately estimated by comparing them with familiar objects which you can measure. For example, if you are sketching in detail a building which you cannot closely approach, use a nearby automobile or railroad car as a scale to estimate the building's dimensions. If the building contains standard-sized windows, these can be used as a scale. Heights of objects can be determined by measuring the length of their shadows at a time of the day when the sun is 45 degrees above the horizon. Use of the principles of geometry, particularly proportional triangles, will permit many dimensions to be measured accurately from a distance.

APPENDIX A

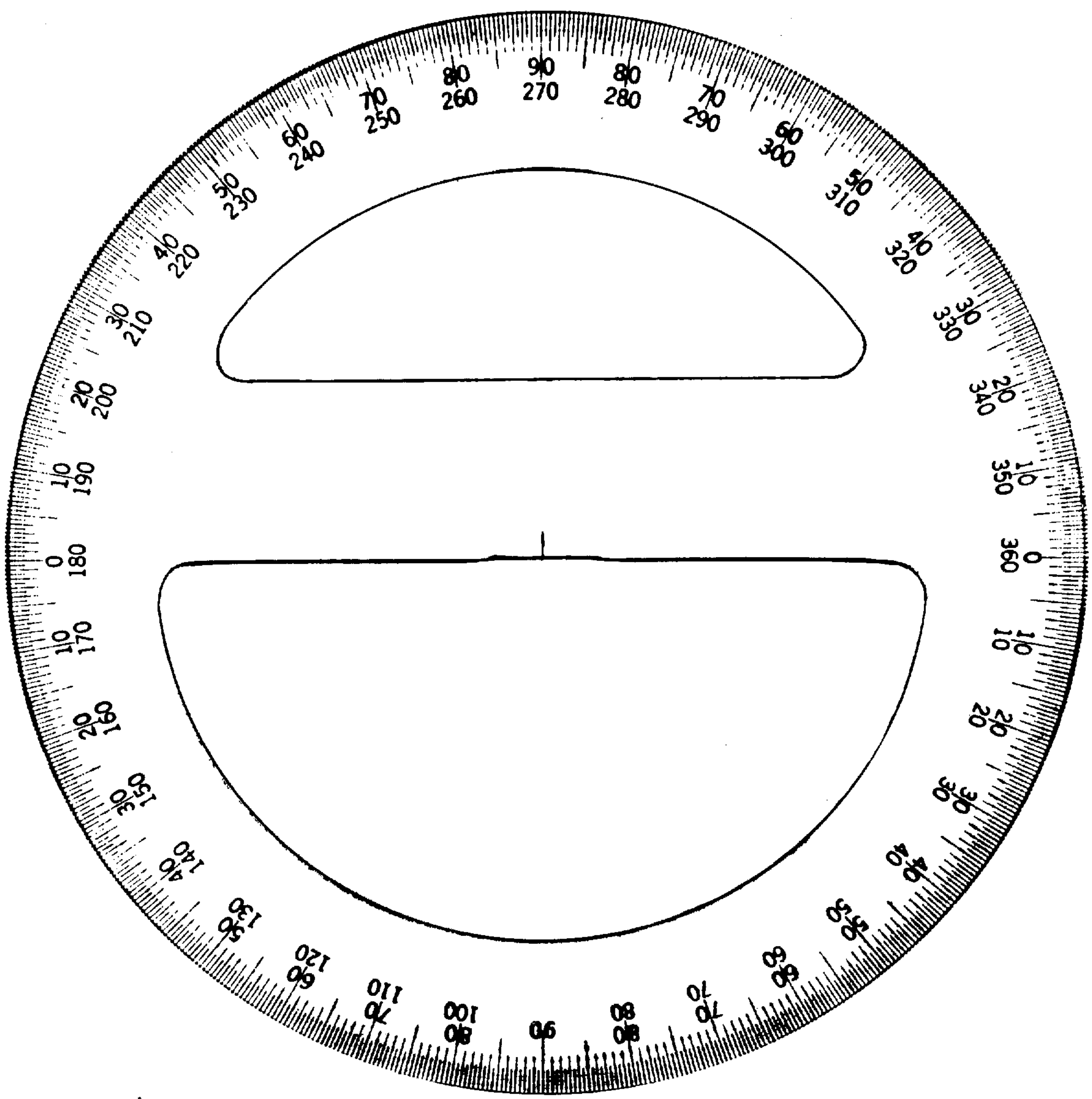


Figure A-I. Protractor

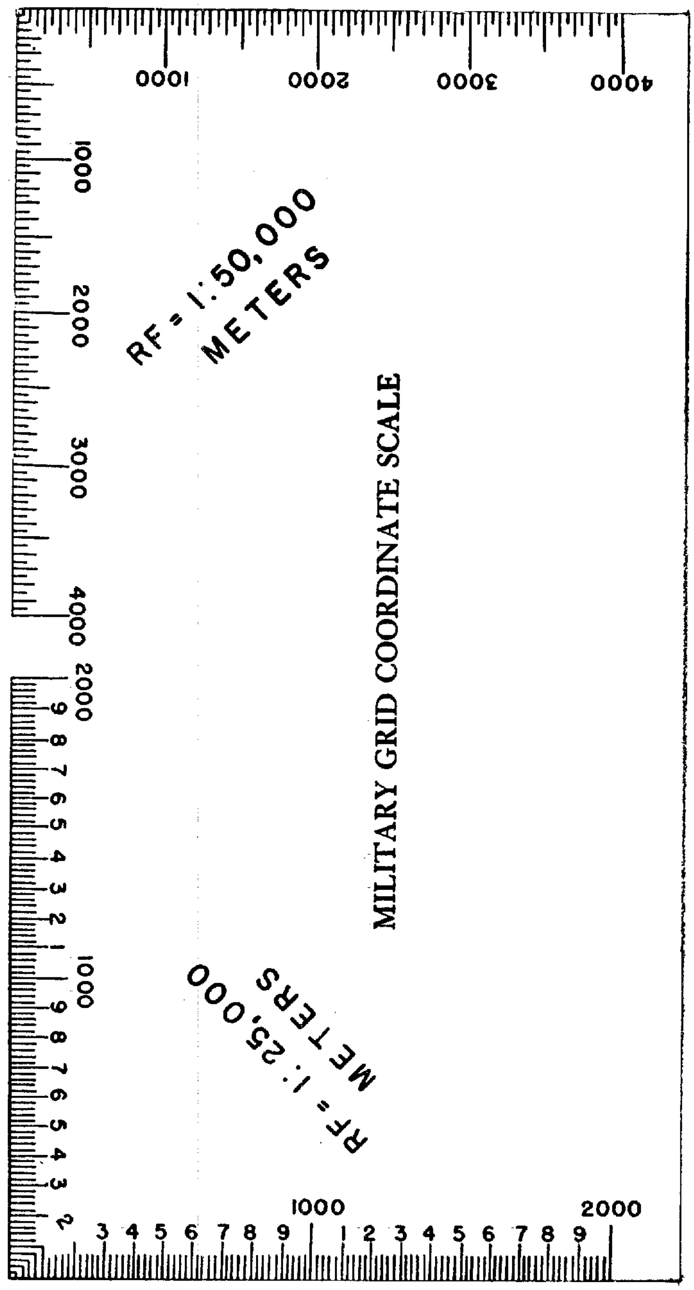
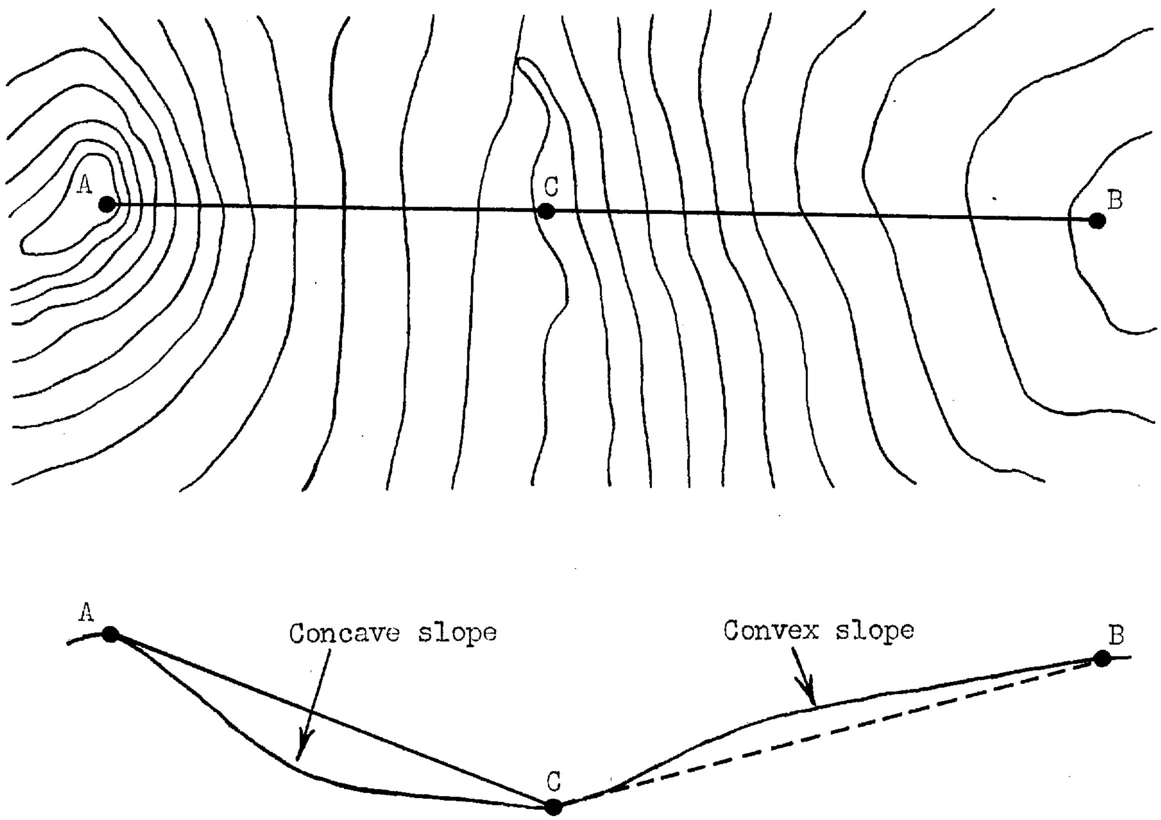


Figure A-II. Grid coordinate scale.



Cross section along line A - B on above map.

Figure 39.
Character of Slopes

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EXERCISE XIII
Contour Interpretation

Refer to the map in Figure 40 regarding the following questions:

1. Is Ihagee Creek flowing generally east or west?
2. Does the ground slope upward more rapidly on the north or south side of Ihagee Creek?
3. What is the elevation of Kite School at grid coordinates 83257527 ?
4. Give the elevation of the buildings at 821727.
5. What is the elevation of the small closed contour at 823752 ?
6. Draw a line between the stream junction at 824742 and the building at 820739. Is the slope along this line convex or concave?
7. Draw a line from the trail on the top of the ridge at 842750 to the stream junction at 849744. Is the slope along this line uniform?
8. Draw a line from the stream junction at 811729 to the road junction at 811735. Is the slope along this line convex or concave?

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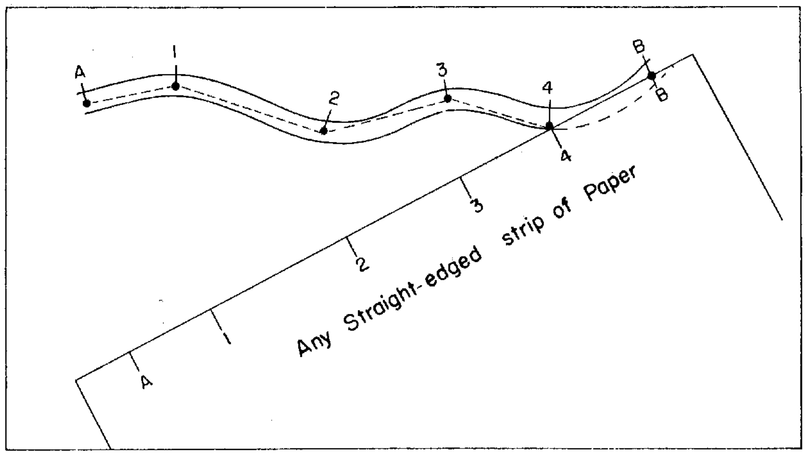


Figure 49.
Measuring Distance Along a Winding Road

4. The scale at which a map is printed is significant for several reasons. Figure 50 shows the relation between distances and areas on maps at three different scales. A smaller scale map (1:20,000) is able to depict a larger area of ground surface on the same size map sheet. The distance between given features appears four times as great at a scale of 1:5,000 as it does at 1:20,000. This makes it possible to include a greater amount of detail at the larger scales. Note in Figure 50 that the map at 1:5,000 includes more contours than the 1:20,000 map, and also shows fences that cannot be drawn at the smaller scale. As the scale becomes smaller, the accuracy of detail cannot be as great. It is not possible to draw as many features to true scale, and symbols such as houses and roads appear to cover more area than they actually do on the ground. Tactical situations usually require use of large-scale maps so that all pertinent features may be shown and detail may be accurate as possible. Since large-scale maps depict a smaller area of the ground, more large-scale map sheets are required to cover a given area than would be necessary at a smaller scale. If operations range over a wide area the large quantity of maps required becomes a problem.

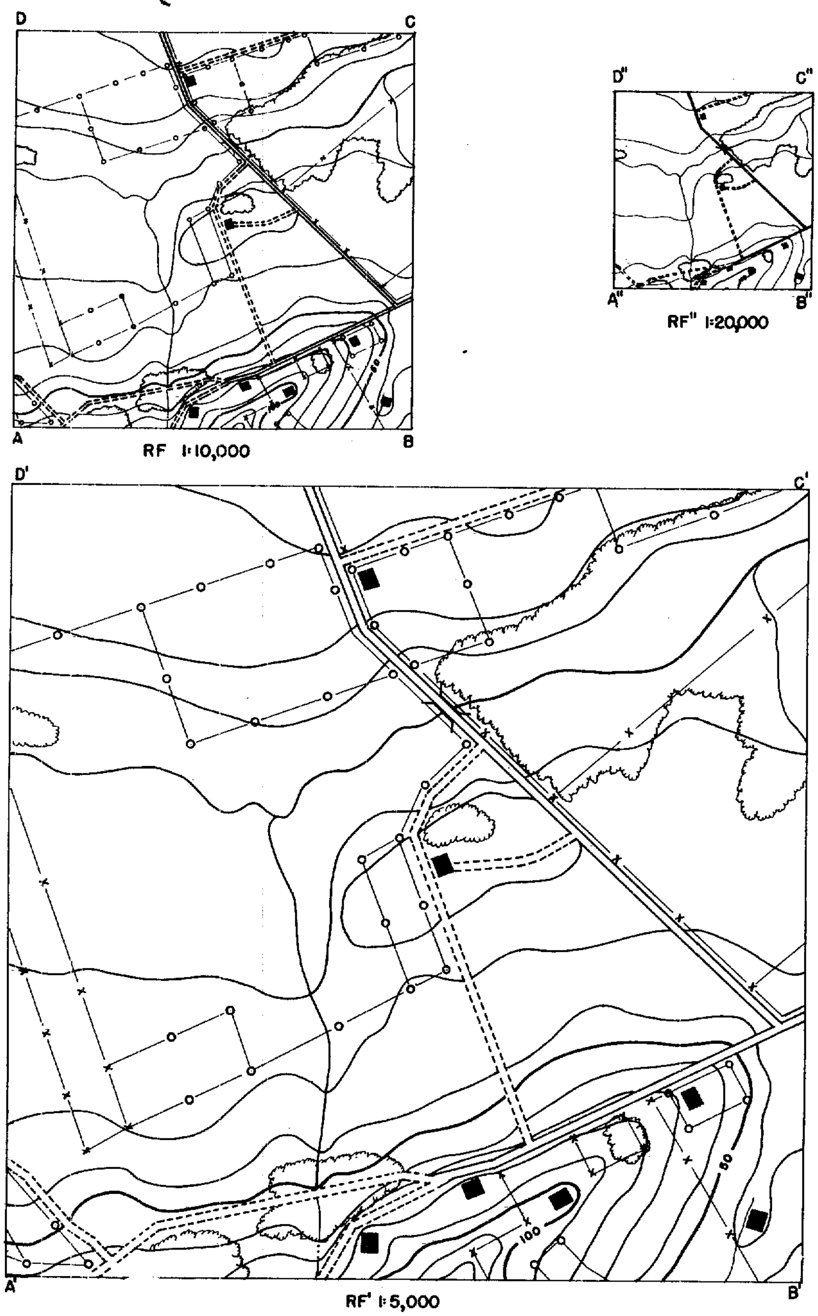


Figure 50. Relation between distances and areas on maps of different scale. (Scales of maps have been reduced in printing.)

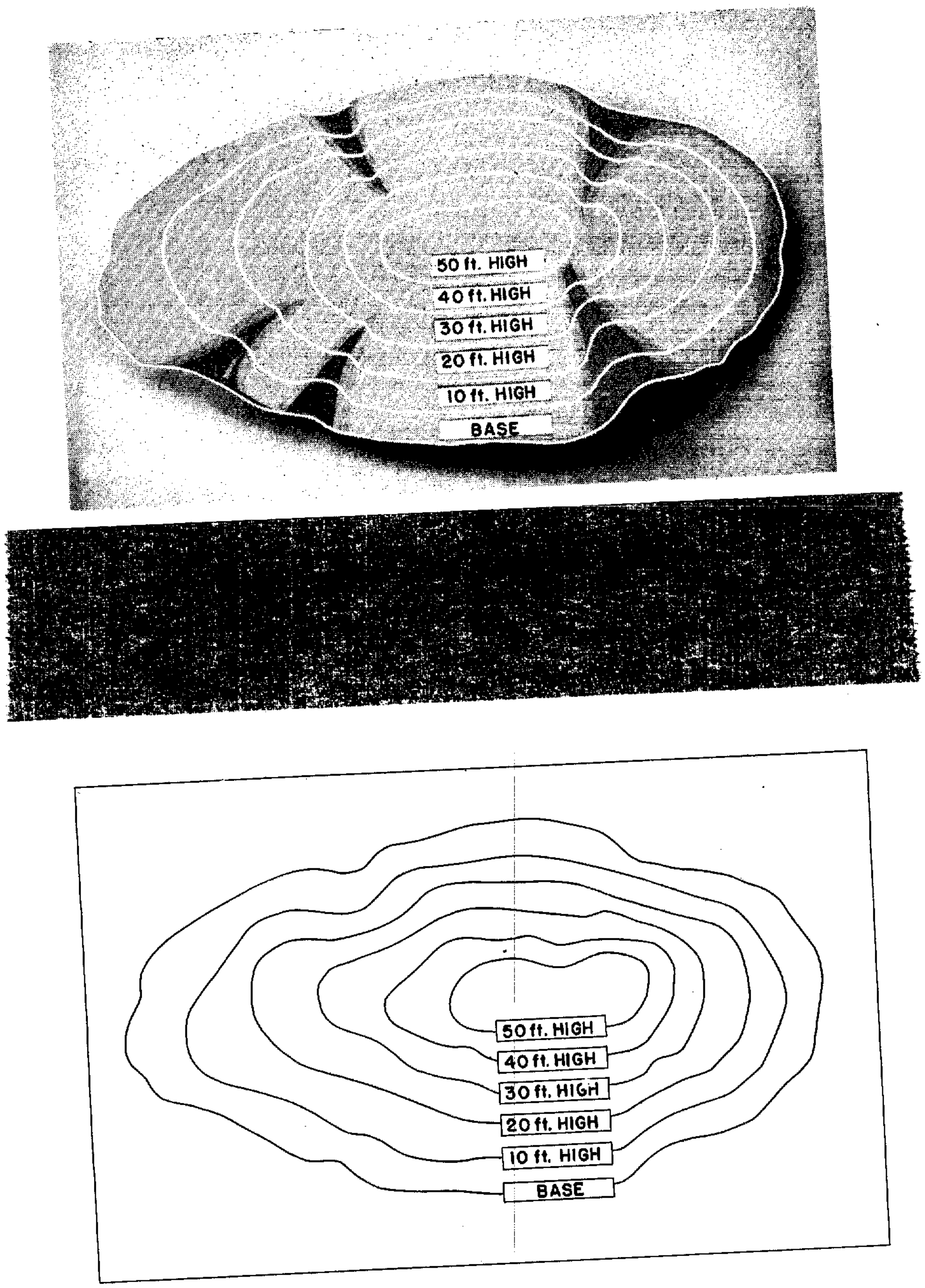


Figure 37. Hill shown by contours.

be the same as that of the contour. If a point falls between two contours, its elevation will be proportional to its distance from the lower to the higher line. For example, in Figure 38, point A is one-fourth the distance from line 60 to line 80, so its elevation is approximately 65. The elevation of point B is about 33.

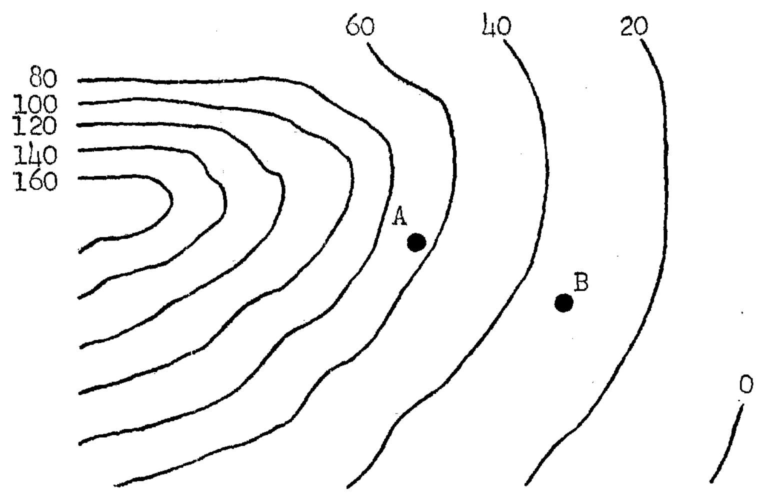


Figure 38.
Elevation of Points

If contour lines appear closer together near the top of a slope and wider apart lower on the slope, the slope is concave and the bottom would be visible from the top. If the contours are farther apart near the top of a slope and closer toward the bottom, it is a convex slope and the bottom probably would not be visible from the top. This is illustrated in Figure 39. Contours that appear to be uniformly spaced indicate a uniform slope. If the contours appear irregularly spaced, the slope is not uniform but undulating.

COORDINATE SCALES

Accurate and rapid readings of military grid coordinates can be made by using a coordinate scale, two types of which are shown in Figure A-III. These scales may be made of paper, metal, or plastic. The coordinate scale must be designed for the scale of the map you are using, e.g., 1:25,000, 1:50,000, etc. The L-shape type is easier to use but the rectangular type is easy to construct by taking a rectangular piece of paper and marking off the subdivisions along two of its edges from the graphic scale on the map.

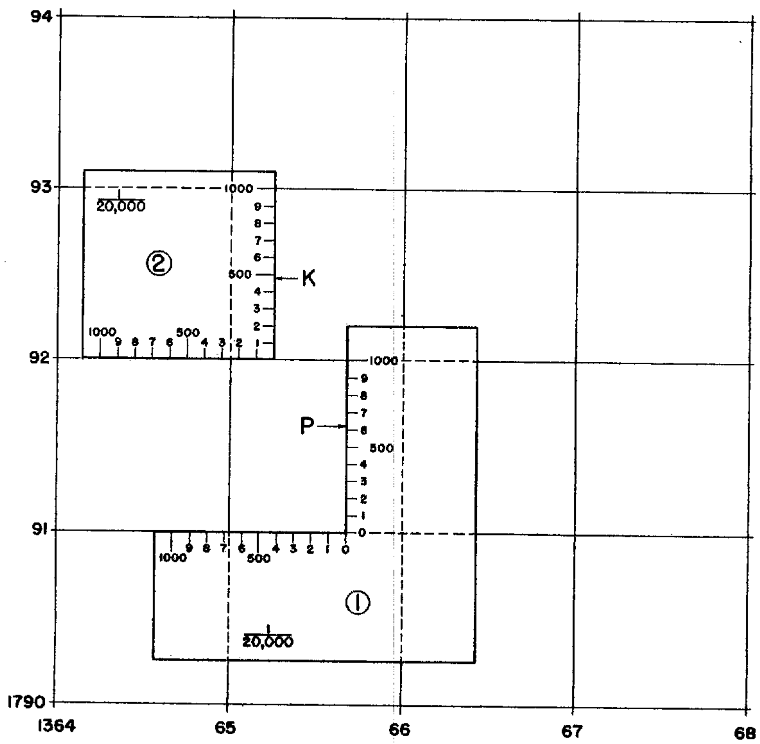


Figure A-III
Locating Points with Coordinate Scales

To read the coordinates of point P in Figure A-III, first identify the square in which P lies and write the coordinates of the lower left (southwest) corner of the square thus (65__91__). Now place the coordinate scale with its horizontal (east-west) edge on the 91 grid line. Keeping this edge on the 91 grid line, slide the scale along until its north-south scale passes through the point P. The additional portion of the easting coordinate is read on the horizontal (east-west) scale, where it is cut by the west boundary of the square (in this case the 65 grid line). The additional portion of the northing coordinate is read on the vertical (north-south) scale, at the point P. These readings are then filled in at the proper places after the coordinates already written down. Reading to the nearest 100 meters, the coordinates of P are 657916. Reading to the nearest 10 meters, the coordinates are 65689162. The coordinates of K are 65259248.

APPENDIX B

Solutions to the Exercises

Exercise I:

1.
   - c. 210975
   - d. 233980
   - e. 217992
   - f. 196982

Exercise II:

1. 271830
2. 241808
3. 276811
4. 255831
5. 296849
6. 235805
7. 234792
8. 254806
9. 277784
10. 239842

Exercise III:

1. N 10° 23' 30" E 105° 42' 00"
2. N 10° 28' 00" E 105° 42' 28"
3. N 10° 16' 00" E 105° 32' 18"
4. N 10° 03' 50" E 105° 34' 06"
5. N 10° 15' 24" E 105° 35' 36"
6. Lap Vo
7. Thanh Phu
8. Hoi An Dong
9. Vinh Thanh
10. Ap Long Dinh

Exercise IV:

1. N $23^{G}, 48^{\backprime}\ 70^{\backprime\backprime}$ E $114^{G}, 62^{\backprime}\ 50^{\backprime\backprime}$
2. N $23^{G}, 45^{\backprime}\ 20^{\backprime\backprime}$ E $114^{G}, 66^{\backprime}\ 25^{\backprime\backprime}$
3. N $23^{G}, 39^{\backprime}\ 25^{\backprime\backprime}$ E $114^{G}, 70^{\backprime}\ 00^{\backprime\backprime}$

Exercise V:

1. N 11° 00' 43.212" E 95°31' 35.868"
2. N 42° 45' 32.4" W 00° 58' 23.2392"
3. S 3° 28' 39.400824" W 59° 34' 15.925944"
4. N $48^{G}\ 05^{\backprime}\ 55.55{+}^{\backprime\backprime}$ - E $18^{G}\ 87^{\backprime}\ 03.33{+}^{\backprime\backprime}$
5. S $17^{G}\ 19^{\backprime}\ 84.5679^{\backprime\backprime}$ E $139^{G}\ 85^{\backprime}\ 55.55{+}^{\backprime\backprime}$
6. N $94^{G}\ 70^{\backprime}\ 28.11728395^{\backprime\backprime}$ E $195^{G}\ 62^{\backprime}\ 96.296{+}^{\backprime\backprime}$

Exercise VI:
1. N 8° 13' E 43° 07'
2. N 38° 06' 27" E 27° 59' 07"
3. N 62° 14' 23" E 103° 17' 03"
4. S 22° 14' 38" W 42° 00' 26"
5. S 9° 47' 04" E 126° 00' 13"

6. N 40° 16' 00" E 21° 31' 59"
7. N 32° 14' 38" W 2° 06' 22"
8. N 18° 06' 30.744" E 108° 42' 46.124"
9. N 14° 01' 53.868" W 10° 26' 42.424"
10. N 39° 59' 48.840" E 42° 09' 50.036"

Exercise IX:
1. Magnetic declination = 3° 55' west of true north
   Grid declination = 2° 00' east of true north

2. Magnetic declination = 2° 08' west of true north
   Grid declination = 3° 10' west of true north

3. 2° 07'

4. 1° 31'

5. $3^G.991$

6. 4° 04'

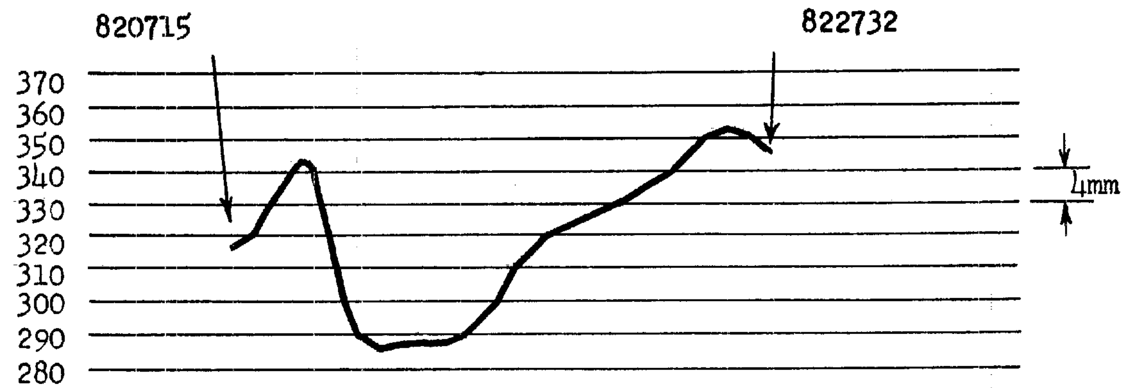
Exercise X:
1. 0° and 360°
2. 90°
3. 180°
4. 270°
5. 180°
6. 270°
7. 0° and 360°
8. 90°
9. 243°
10. 245^G
11. 81°
12. 189^G
13. ~~346°~~ 14°
14. 63° 45'
15. $303^G.96$

Exercise XI:
1. 38200218
2. 39750243

Exercise XII:
1. 82627288

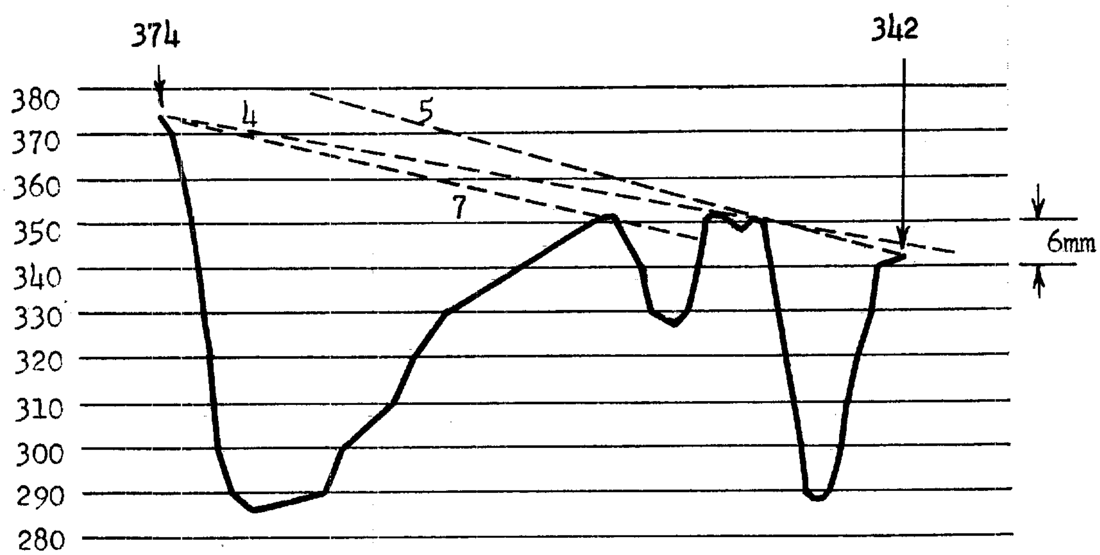
Exercise XIII:
1. East
2. South
3. 410
4. Approximately 325
5. 420
6. Convex
7. No
8. Concave

Exercise XIV: 1.



2. No

3.



4. Yes

5. Yes

6. Spot height 374

7. Yes

Exercise XV:

1. a. Refer to the declination diagram and determine the magnetic declination for 1959 to be 25°51' (subtract an additional 6' for each year beyond 1959).

   b. Draw a straight line from the pivot (P) point to 25° 51' on the protractor scale.

   c. Lay the compass on the map so the front and rear sights fall directly over this magnetic north line, with the front sight toward the north.

   d. Rotate the map and compass together until the north pointer falls directly under the fixed index mark. The map is then correctly oriented.

2. By inspection. I would face up the road toward Kite school and rotate the map horizontally until the school appeared forward of my position and the road on the map appeared parallel to the road ahead of me. Then the buildings and side road would appear to my left and the fence line perpendicular to the main road would run off to my left rear. If all these features appeared in their proper relationship to each other, the map would be oriented correctly.

3. From the declination diagram I would determine that magnetic north is 3° 45' west of grid north. Using the protractor (Figure A-I) I would lay off to the left of one of the north-south grid lines an angle of 3° 45' and draw this magnetic north line slightly longer than my compass.

Exercise XVI:

1. 7.53 kilometers or 4.68 miles
2. 13.1 kilometers or 8.12 miles
3. 2.85 kilometers or 1.76 miles
4. 48 sheets
5. 1:250,000
6. 1:25,000

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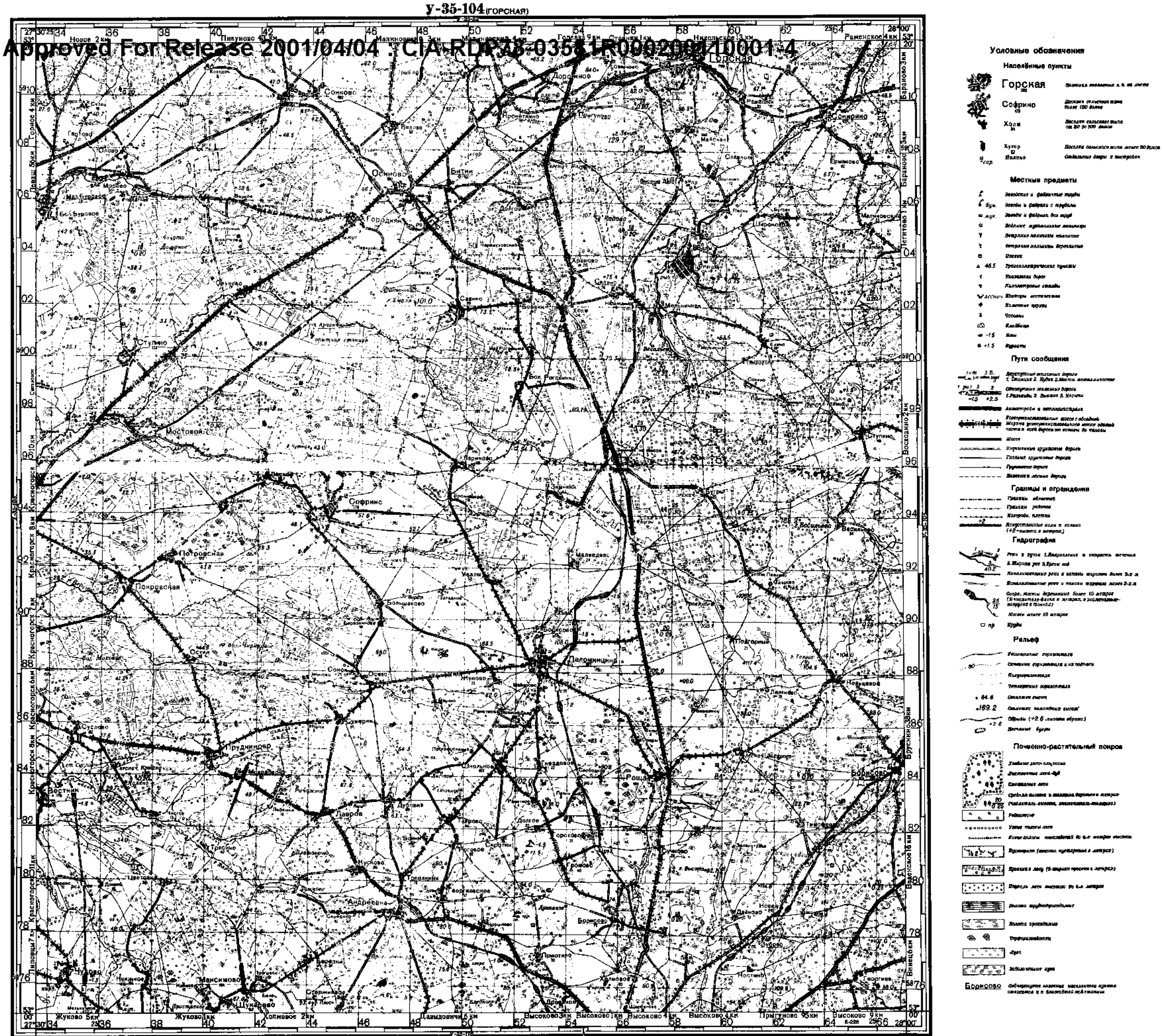
У-35-104 (ГОРСКАЯ)



1:100 000

в 1-м сантиметре 1 километр

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При высоте сечения 20 м

При высоте сечения 100 м

Главное управление геодезии и картографии МВД СССР
Москва
1953 г.

Составлено в 1952 г.
Отпечатано в 1953 г.

Составила Сгукова Л. В.
Редактор Коротнова Е. М.
Директор Рижской картографической фабрики Воробьев И. Н.
Подписано к печати 17.6.53 г. Формат бумаги 52×52
Объем 1 п. л. Т-03992 Заказ № 135 Тираж 4000
Рижская картографическая фабрика ГУГК