CHAPTER 5

LAND NAVIGATION

Terrain is another name for a piece of ground. For our purposes, it is a region or territory viewed for its suitability as a battleground. How you make use of the terrain-its texture, even its color at different times of the day-affects everything you or the enemy do or can do. Both you and the enemy have the terrain of the battlefield in common. More often than not, victory goes to whoever understands and uses the terrain best.

Usually, the terrain dictates troop movements and formations, positions to be defended, and locations of weapons. You cannot memorize definite rules to cover every situation. However, there are certain principles discussed in this chapter that, when applied intelligently, will result in sound solutions or decisions. Knowledge of these principles is not enough to give you the advantage. You must know the terrain intimately to use it properly. Other than making a personal reconnaissance of the terrain, you must be thoroughly familiar with the use of commercially prepared maps as well as maps drawn hastily in the field. You must also interpret signs and symbols used on maps, prepare field sketches and overlays, and use the lensatic compass properly.

TERRAIN APPRECIATION

Terrain appreciation is the analysis of an area to determine the effect that the terrain features have on probable military operations by either of the opposing forces. Terrain can be viewed with either offensive or defensive intentions in mind. However, regardless of the type of mission, each Seabee leader must evaluate the terrain for both offense and defense. Then the Seabee leader can anticipate the enemy's analysis of the situation as well as his own. Information on the terrain may be acquired through various sources, but a physical reconnaissance of the area is the most important and reliable method of obtaining accurate information. When a physical reconnaissance is not possible or additional information is desired, it may be provided by one or more of the following sources:

1. Aerial reconnaissance and photographs
2. Maps of the area
3. Terrain models provided by higher authority
4. Intelligence reports
5. Patrolling
6. Friendly natives, undercover agents, or captured enemy prisoners

COMPONENTS OF TERRAIN

In military terminology, terrain is simply the ground over which we intend or propose to. fight. To a military man, the word *terrain* is an all-inclusive term, referring not only to the ground itself, but to all other conditions that influence the ability of the combatant to carry out an assigned mission. For the sake of simplicity, terrain has two major aspects. The first is weather, climate, and season; the second is topography.

WEATHER CLIMATE, AND SEASON

WEATHER is the day-to-day changes in atmospheric conditions. CLIMATE is the average weather over an extended period of time. SEASONS are characterized by particular conditions of weather, such as summer and winter in the United States or the rainy and dry seasons in Southeast Asia. Of these three elements, weather is the most important consideration from a tactical viewpoint. For long-range planning or in the absence of weather information, climatological and seasonal data may be used to estimate weather conditions.

The Elements of Weather

Weather consists of several atmospheric elements, each affecting tactics in its own way. These elements are as follows:

1. TEMPERATURE. The degree of hotness or coldness in a geographic area.

2. HUMIDITY. The percentage of water vapor in the air.

3. VISIBILITY. The ability to see both horizontally and vertically. It is influenced by fog, haze, heat refraction, clouds, or precipitation.

4. PRECIPITATION. The depositing of moisture (rain, mist, snow, sleet, hail) from the atmosphere upon the surface of the earth, expressed in kind and amount.

5. WIND. The movement of air within the atmosphere. It is expressed as strength (velocity) and direction.

6. PHASES OF THE MOON. Usually, phases of the moon are expressed in quarters. The first quarter is between the new moon and the full moon; the second, or last quarter, between the full moon and the new moon. The two phases have a direct bearing on night visibility and the amount of rise and frill of the tides.

The Effect of Weather on Tactics

Weather has a direct effect on the visibility, the movement, and the use and effect of weapons. Horizontal visibility may be materially reduced (resulting in reducing the observation of the enemy or the effect of your fire on them) by fog, haze, heat refraction, or precipitation. Vertical visibility may be restricted by fog, precipitation, or a large mass of low-lying clouds, thus reducing the effectiveness of air support or aerial reconnaissance. Ease of movement, both logistical and tactical, on roads or cross-country may vary drastically from day to day because of precipitation and temperature changes. A heavy rain may change a passable area into an impassable quagmire; but a severe temperature drop may cause the same quagmire to frieeze, thus aiding movement.

Weather affects weapons, both in employment and in the effectiveness of the weapon itself. The trajectory of artillery and mortar rounds is greatly influenced by temperature and humidity. Extreme cold and hot weather require special treatment and handling of gasoline engines, thus affecting the use of equipment and vehicles. The effects of weather are particularly noticeable in air and naval weapon systems support. Air support may be restricted or prevented entirely by clouds, fog, or heavy precipitation. Fog, snow, or heavy rainfall reduce visibility; therefore, naval gunfire support cannot be delivered as effectively, and new targets cannot be rapidly located and engaged.

TOPOGRAPHY

Topography consists of the physical aspects of the surface of the earth and includes such features as relief and drainage, vegetation, surface materials, and cultural features.

Relief and Drainage

RELIEF is the term given to the differing areas of elevation and depression on the surface of the earth. DRAINAGE refers to those areas of surface depression that serve as water runoffs or collection points, such as marshes, swamps, streams, rivers, ponds, and lakes. Knowledge of the general shape of the land is gained through a detailed study of the relief and drainage features. The steepness of slopes; the height and size of hill masses; the depth, the width, and the length of drainage features; and the sizes of valleys and draws are major features to consider when studying the terrain of a given area. These irregularities in the surface of the earth influence tactics by the degree of observation they provide the opposing forces, the ease or difficulty of movement, and the degree of protection provided against enemy fire. Flat ground provides equal observation for the opposing forces; normally, high ground in rolling or mountainous terrain provides for better observation.

Any advances made parallel to a series of ridges or to a river or stream are mechanically easier than movement perpendicular to them. The steepness of a slope may limit movement; tanks, for instance, cannot climb slopes greater than 30 degrees.

Flat ground offers little protection against enemy fire, but rolling ground will, particularly against flat-trajectory weapons.

Vegetation

Vegetation is classified for practical purposes as either NATURAL or CULTIVATED. Natural plant life includes all types of grasses, bushes, and trees growing without the assistance of man; cultivated vegetation includes all crops and orchards tended by man. Density, height, and types of growth, as well as the diameter of tree trunks, are significant features when you are studying vegetation.

Although vegetation may restrict vision, it offers concealment and limited cover. Of course, the thicker the growth, the harder it is for the forces to move about.

Surface Materials

Surface materials are studied to determine the trafficability of an area. “Trafficability” is defined as the ability of a soil in its normal state to support vehicular traffic moving cross-country or on unimproved roads and trails. In general, all types of soil, except very loose sand, afford good trafficability when dry. However, soils

are seldom completely dry. Water may change soil from a hard, baked clay to slippery, impassable mud within a matter of minutes, especially in tropical areas. Another aspect to consider, along with the types and condition of the soils, is the slope of the ground, the type of vegetation, and the roughness of the surface.

Cultural Features

CULTURAL FEATURES include all the works of man, such as towns, airfields, roads, railroads, and bridges. For military purposes, man-made features are considered an integral part of terrain. Cities and towns are frequently the objectives of an attacking force. For tactical purposes, cultural features may be centers of resistance as well as physical obstacles in your path. Roads, railroads, and bridges are vulnerable links in logistics and communication networks.

MILITARY ASPECTS OF TERRAIN

Various combinations of weather and topography give certain qualities to an area. These qualities, known as the MILITARY ASPECTS OF TERRAIN, must be closely evaluated by each unit leader. These qualities determine to a large degree how he employs his forces and weapons. You can remember these military aspects of terrain by using the acronym KOCOA.

K – Key terrain features

O – Observation and fields of fire

C – Cover and concealment

O – Obstacles

A – Avenues of approach

KEY TERRAIN FEATURES

Key terrain is any locality or area that provides the possessor a marked advantage over the enemy. Usually, the factors that make a feature or an area key terrain are superior observation and fields of fire. Obstacles may be considered key terrain when their possession by one force prevents the movement of the opposing force. In some areas, such as mountains and jungles, where movement depends on established roads and paths, routes of communications could be key terrain. A bridge over an unfoldable river could be key terrain, particularly when its seizure eliminates the need for an assault crossing. An airfield could be key terrain when its seizure facilitates the success of local operations or serves as a base to support future operations.

In selecting key terrain, the unit leader is beginning to tie his mission to the ground. Inasmuch as key terrain features offer an advantage to one or both combatants, it is apparent that the defender will strive to retain them while the attacker tries to seize them. For this reason, key terrain is often assigned as the objectives of attacking units; conversely, key terrain aids the defender in disposing his forces to best maintain his battle position.

Selection of key terrain features varies according to the mission. In the attack, the unit leader selects key terrain features forward of the line of departure. In the defense, the terrain that must be held to maintain the integrity of the battle position is designated as key terrain.

Selection of key terrain also varies at the different levels of command. For example, at force level, a large city may offer a marked advantage as a communications center or as a base for supply and maintenance facilities. At division or regiment level, high ground dominating the city may be important for observation and fields of fire. At battalion, company, and lower echelons, key terrain might be hills and valleys within the general high ground around the city.

OBSERVATION AND FIELDS OF FIRE

OBSERVATION of the battlefield is essential to bring effective fire on the enemy, to control maneuvering of your troops, and to prevent being surprised by the enemy. Observation is classified as either long or short range. Long-range observation is that which provides observation in excess of the effective range of small-arms fire (usually over 400 meters). Short-range observation covers the immediate foreground and extends to the effective range of small-arms fire. Observation is limited or denied by such factors as fog, heavy precipitation, heat refraction, darkness, vegetation, cultural features, and relief.

FIELDS OF FIRE are areas into which your weapons can be fired effectively. An ideal field of fire for the defense would be gentle sloping ground, fitted to the trajectory of your weapons, and on which the enemy can be seen with no protection from your fire. This situation is rarely encountered. However, you can improve the natural fields of fire by cutting or burning weeds, grass, and crops; by clearing brush and trees; by demolishing buildings; and by cutting lanes through woods. The commander must exercise caution in ordering such work, since obviously constructed fire

lanes can disclose the location of your positions to an observant enemy.

Observation and fields of fire are so closely related that they are considered together. They are not synonymous, but fields of fire are based on observation, since the enemy must be seen to bring effective fire on him. These aspects are particularly important to the defender. The primary considerations for choosing a defensive position are maximum observation and long fields of fire.

COVER AND CONCEALMENT

COVER is shelter protection from enemy fire, either natural or artificial. Geographical relief features, drainage areas, cultural features, and other artificial shelters provide cover. Cover from flat trajectory fire is best exemplified by the concept of reverse slope; that is, when there is a projection of relief, such as a hill, between you and the enemy. Cover must be considered in relation to the types of fire encountered. For example, a trench offers excellent protection against rifle fire, but only limited protection against mortar or artillery fire.

CONCEALMENT is protection from observation. Vegetation, cultural features, geographical relief features, drainage areas, weather conditions, and darkness can provide protection from observation. Frequently, you can obtain concealment by properly evaluating and using just the terrain. At other times, you may need artificial means (camouflage) in addition to natural, available concealment.

Concealment is the reverse concept of observation. Since the defender usually has the opportunity to choose the ground he wishes to defend, he selects positions that take maximum advantage of natural cover and concealment, adding field fortifications and natural concealment with camouflage to improve the position. It is important that you judge your own cover and concealment by looking at it from the point of view of a potential attacker.

OBSTACLES

Obstacles are obstructions that stop or divert troop movement. Common natural obstacles of military value include mountains, rivers, streams, lakes, marshes, gullies, steep inclines, and heavily wooded areas. Common artificial obstacles include minefield, cut and falls, trenches, antitank ditches, roadblocks, barbed wire, blown bridges, and road craters. The proper evaluation of natural obstacles permits the most effective use of artificial obstacles. Obstacles perpendicular to the advance route of the enemy generally favor the defending force. Obstacles parallel to the advance of the enemy may favor the enemy by protecting his flanks, although the obstacles may also limit his lateral movement. The effectiveness of an obstacle must be carefully examined. An obstacle by itself is rarely an absolute block to military movement by a determined enemy. A defender who puts full faith in an obstacle by itself stands the risk of being surprised by enemy movement over or through that obstacle. Maximum effectiveness is gained from an obstacle kept under observation and fire.

AVENUES OF APPROACH

An avenue of approach is a terrain feature or combination of features that offer a maneuvering unit a suitable route of movement to their objective. The desirable characteristics of an avenue of approach are listed below.

- EASE OF MOVEMENT toward the objective
- COVER and CONCEALMENT from the fire and observation of the defender
- FAVORABLE OBSERVATION and fields of fire for the attacker
- Adequate ROOM FOR MANEUVER and dispersal by the attacking unit

You, as a defender, must pay particular attention to all avenues of approach. These approaches into your Seabee position represent potential weak spots in the defense, and Seabees must be positioned to block and cover them effectively. As a defender, you must also consider the use of these avenues of approach by your own forces should you wish to launch a counterattack.

MAPS AND THE COMPASS

In a combat situation, your life may depend upon your ability to read and use a map and compass. When you are on a night patrol and become separated from the rest of the patrol, you must find your way back to friendly lines by yourself. This could be next to impossible without using a map that shows the approximate location of friendly forces. With a map and compass, you should be able to locate your position and then follow a route to your destination.

In this phase of our discussion, we discuss military maps first. Then, special attention is given to topics that should help you to read maps accurately and intelligently. Later, we discuss the use of a lensatic

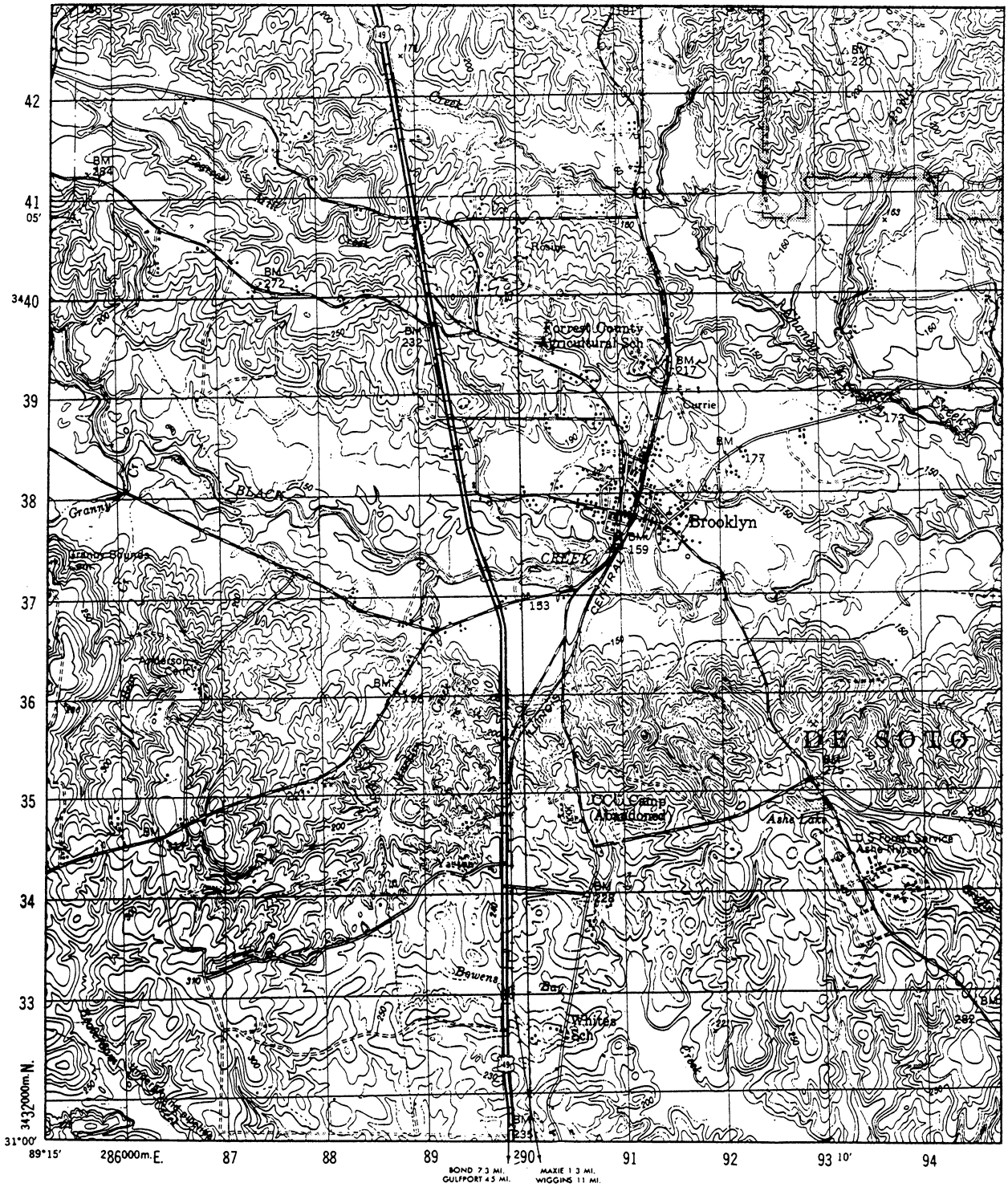

Figure 5-1.—Portion of military map.

compass. Finally, we include instruction on ways to orient a map with a lensatic compass.

MAPS

A map is a small-scale, flat-surfaced representation of a part of the surface of the earth. Man-made and natural features are shown by the use of symbols, lines, colors, and forms. (See fig. 5-1.) Maps show the location and distances between ground features, such as towns, populated areas, roads, airfields, streams, and other lines of communication. They also indicate variations in the landform and the height of natural features.

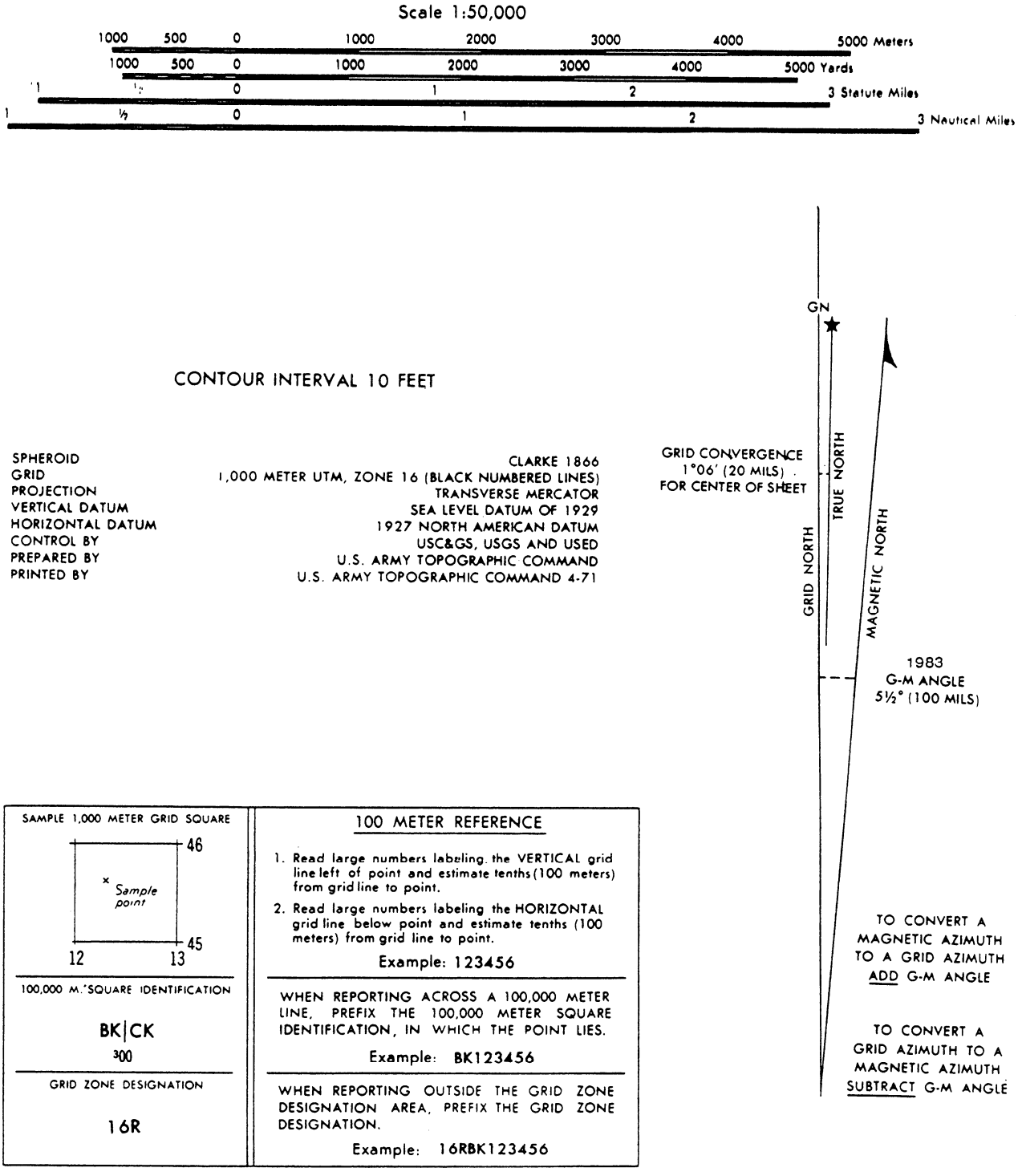

Figure 5-1.—Portion of military map–Continued.

Some of the types of maps you will use areas follows:

- TOPOGRAPHIC MAP. This map portrays terrain and landforms in a measurable form as well as the horizontal positions of the features represented. The vertical positions, or relief, are normally represented by contours. On relief maps, the elevations and contours are measured from a specified vertical datum plane, usually mean sea level.

- PLANIMETRIC MAP. This map presents only the horizontal positions for the features represented. The omission of relief in a measurable form distinguishes it from a topographic map.

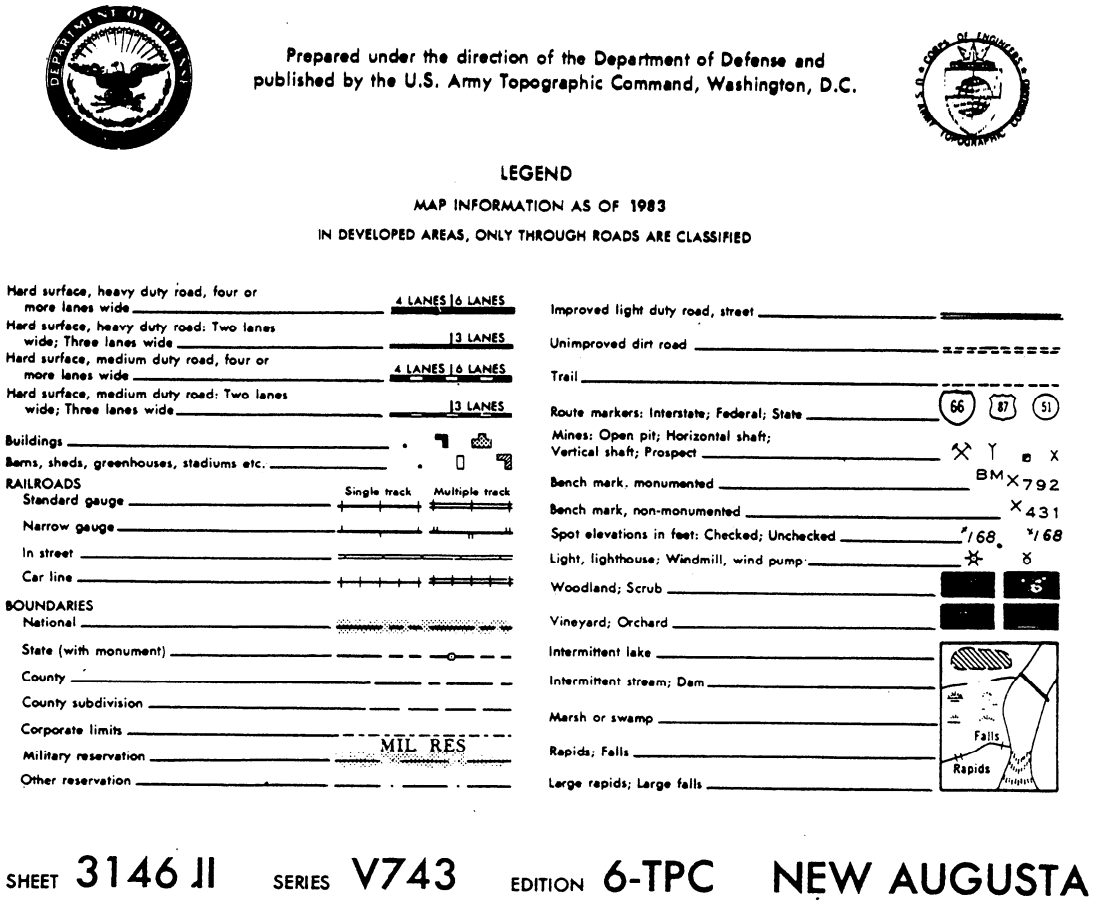

Figure 5-1.—Portion of military map–Continued.

- PHOTOMAP. This map is a reproduction of an aerial photograph or a photomosaic made from a series of aerial photographs. Photomaps show grid lines, marginal data, place names, route numbers, important elevations, boundaries, approximate scale, and approximate direction.

- PICTOMAP. A map on which the photographic imagery of a standard photomap has been converted into interpretable colors and symbols.

Reference Systems

One of the oldest reference systems is based upon the geographic coordinates-meridians and parallels. MERIDIANS are great circles of north-south rings crossing the equator at right angles and converging at the North and South Poles. (See fig. 5-2.) One meridian that runs through Greenwich, England, is known as the prime meridian. Meridians are used to measure LONGITUDE–the distance of a point east or west of the prime meridian. PARALLELS are great circles of

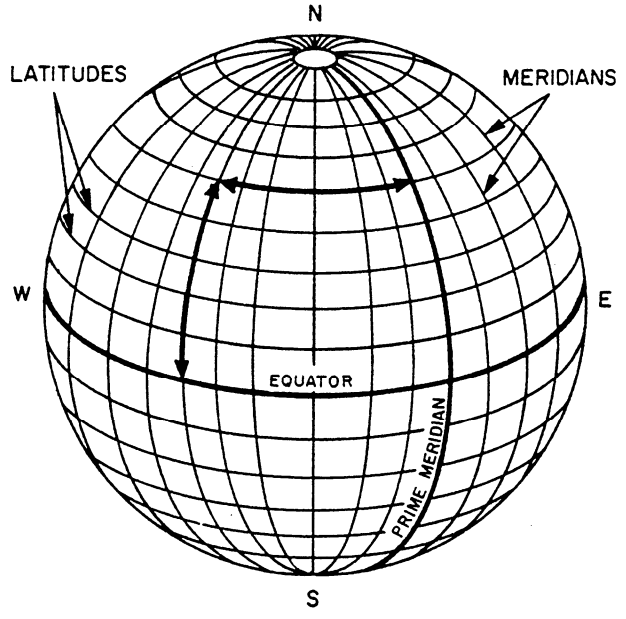

Figure 5-2.—Reference lines.

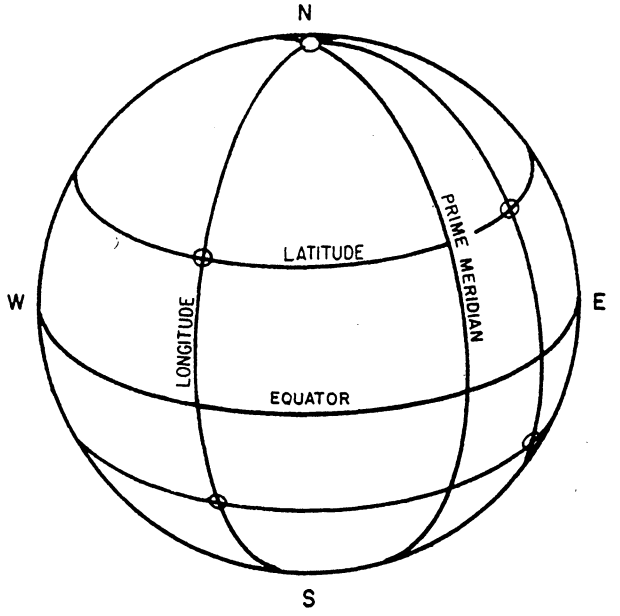

Figure 5-3.—Position location.

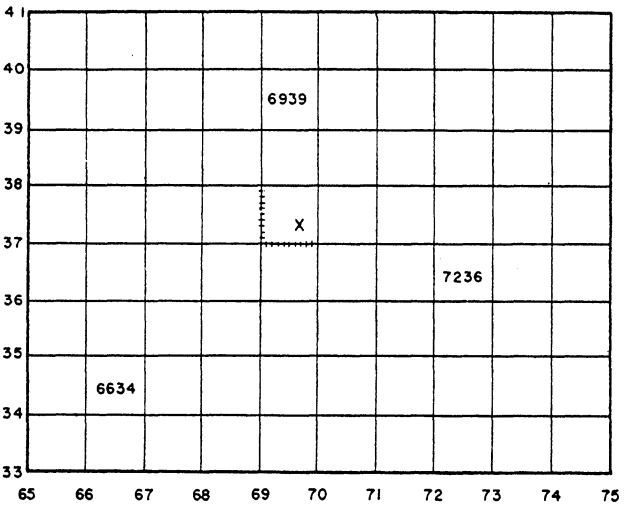

Figure 5-4.—Grid system.

east-west rings running parallel to the equator. (See figs. 5-2 and 5-3.) Parallels are used to measure LATITUDE–the distance of a point north or south of the equator. Using meridians and parallels, you can locate any point on the surface of the earth.

Geographic coordinates are expressed in angular measurement. The earth is divided into 360 degrees; each degree into 60 minutes; and each minute into 60 seconds. The degree is symbolized by °; the minute by´; and the second by´´.

Starting with 0° at the equator, the parallels of latitude are numbered to 90° both north and south. The extremities are the North Pole at 90° north latitude and the South Pole at 90° south latitude. Latitude can have the same numerical value north or south of the equator, so the direction N or S must always be given.

Starting with 0° at the prime meridian, longitude is measured both east and west around the world. Lines east of the prime meridian are numbered from 0° to 180° and are identified as east longitude. Lines west of the prime meridian are numbered 0° to 180° and are identified as west longitude. The direction E or W must always be given to longitude. The line directly opposite the prime meridian, 180°, may be referred to as either east or west longitude.

Grids

Military maps are divided into grids to provide a uniform system for referencing and making measurements. Military grids consist of two sets of equally spaced parallel, straight lines intersecting at right angles and forming a series of squares. Each grid line is an even interval of the selected measurement unit, such as yards or meters. A portion of a military grid, or map, is shown in figure 5-1. The dimensions and orientation of different types of grids vary, but all military grids have three things in common:

1. They are all true rectangular grids.

2. They are superimposed; that is, drawn on top of the geographic projection.

3. They permit linear and angular measurements.

The regularly spaced lines that make up the grids on any large-scale map are divisions of the 100 000-meters square; the lines are spaced at 10 000- or 1000-meter intervals. Each of these lines is labeled at both ends with a number showing its relation to the origin of the zone. For the 1000-meter grid, except for the numbers labeling the first grid line in each direction from the southwest corner of the sheet, the last three digits (000) of the number are omitted. (See fig. 5-1.) Two digits of the numbers are printed in large type, and the same two digits appear at intervals along the grid line on the face of the map. They are called the PRINCIPAL DIGITS and represent the 10,000 and 1,000 digits of the grid number; they are of major importance to the map reader because they are numbers he uses most often for referencing points. The smaller digits complete the COORDINATES of the grid lines, but they are rarely used for point designation. On sheets with grid line spacing at 10000 meters, only one principal digit is shown, representing the 10,000 digit of the grid number.

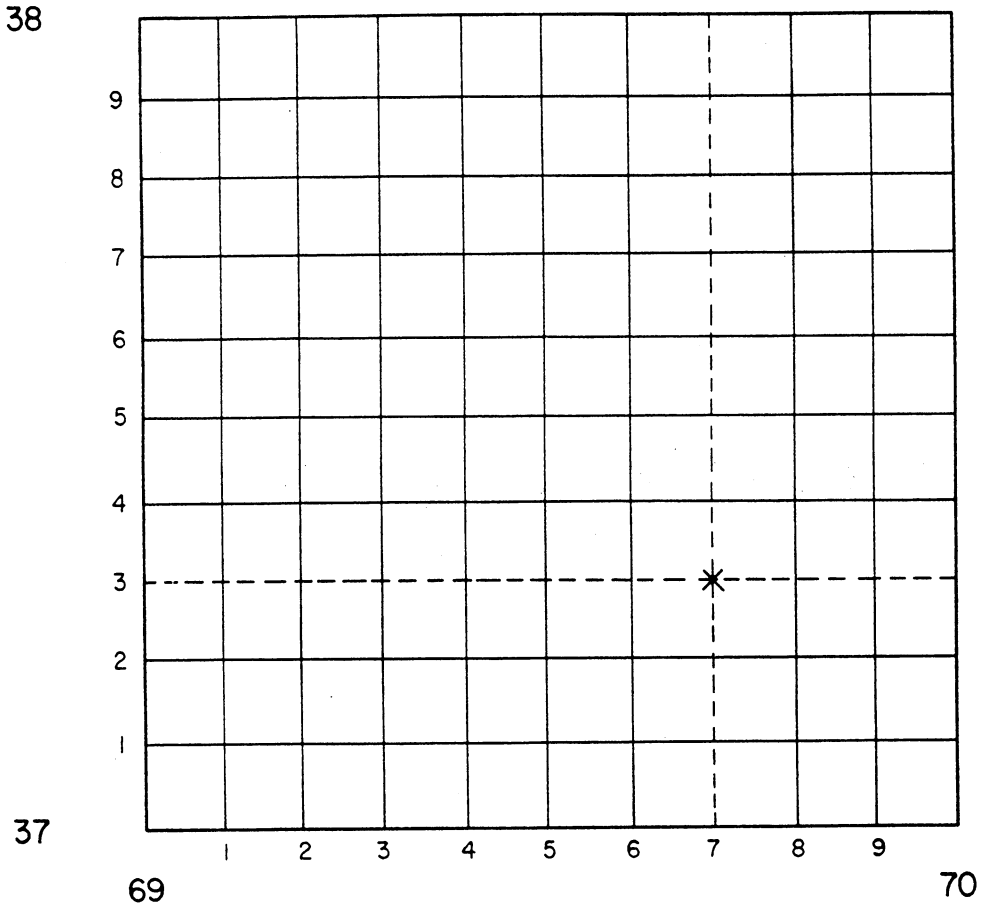

Figure 5-5.—Grid square, close-up.

The designation of a point is based on the military principle of "Read RIGHT then UP." The precision desired determines the number of digits to be read beyond the principal digits. Remember that the term *grid coordinate* often indicates both the 100 000-meters-square identification and the desired number of digits. In many instances, it is a tactical requirement that the 100 000-meters-square identification be included in any point designation. Figure 5-4 shows a section of a simple grid system. Each line is numbered, starting at the lower left-hand corner, reading to the right and up. Remember, when you read a military map, you should always read from left to right and from bottom to top. Three squares in figure 5-4 have numbers in them to identify that particular grid square. The letter *X* has been placed in grid square 6937. To locate this point more precisely, see figure 5-5. You can see that the sides of the grid square have been divided into ten parts. This can be done by eye or with a scale. As shown in this figure, the X is located at coordinate 697373. The grid coordinates are written as one number but always contain an even number of digits. Examples are 6937 and 697373.

Elevation and Relief

A knowledge of map symbols, grids, scale, and distance provides enough information to identify two points. You locate them, measure between them, and determine the length of time required to travel between them. But what happens if there is a 300-foot cliff between the two points? The map user must also become proficient in recognizing the various landforms and irregularities of the surface of the earth. Then he is able to determine the elevation and differences in the height of all terrain features.

1. DATUM PLANE. This is a reference from which vertical measurements are taken. The datum plane for most maps is mean, or average, sea level.

2. ELEVATION. This is defined as the height (vertical distance) of an object above or below a datum plane.

3. RELIEF. Relief is the representation of the shape and height of landforms and the characterization of the surface of the earth.

The elevation of points and the relief of an area affect the movement and deployment of units by limiting the route of travel, their speed of movement, and the ease or difficulty of attacking or defending an area. Also relief affects observation, fields of fire, cover, concealment, and the selection of key terrain features.

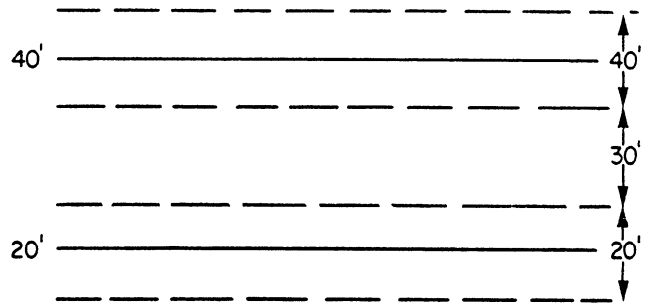

Figure 5-6.—Estimating elevations between contour lines.

Contour Lines

There are several ways of indicating elevation and relief on maps. The most common way is by contour lines. A CONTOUR LINE is a line representing an imaginary line on the ground along which all points are at the same elevation.

Contour lines indicate a vertical distance above or below a datum plane. Starting at sea level, normally the zero contour, each contour line represents an elevation above sea level. The vertical distance between adjacent contour lines is known as the CONTOUR INTERVAL. The amount of the contour interval is given in the marginal information. On most maps, the contour lines are printed in brown. Starting at zero elevation, every fifth contour line is drawn with a heavier line. These are known as INDEX CONTOURS. Someplace along each index contour, the line is broken and its elevation is given. The contour lines falling between index contours are called INTERMEDIATE CONTOURS. They are drawn with a finer line than the index contours and, usually, do not have their elevations given.

Using the contour lines on a map, you may determine the elevation of any point as follows:

1. Find the contour interval of the map from the marginal information, and note both the amount and the unit of measure.

2. Find the numbered contour line (or other given elevation) nearest the point for which the elevation is being sought.

3. Determine the direction of slope from the numbered contour line to the desired point.

4. Count the number of contour lines that must be crossed to go from the numbered line to the desired point and note the direction-up or down. The number of lines crossed multiplied by the contour interval is the distance above or below the starting value.

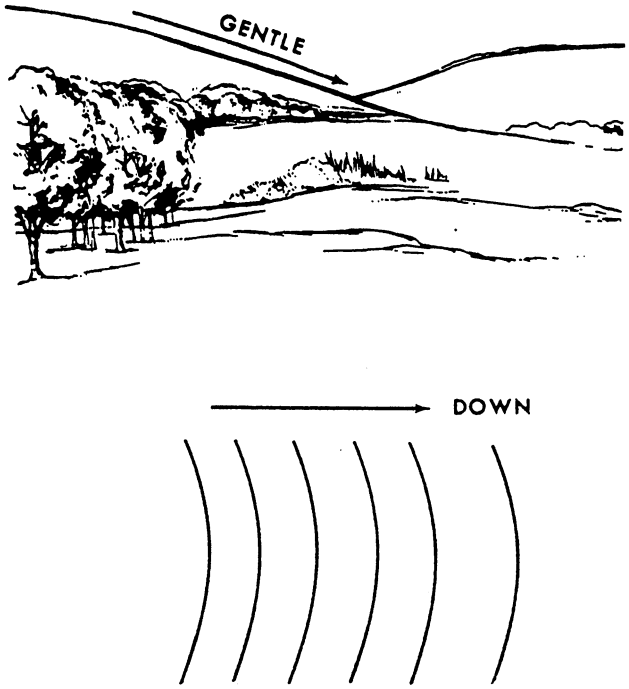

Figure 5-7.—Uniform, gentle slope.

When the desired point is on a contour line, its elevation is that of the contour.

For a point between contours, most military needs are satisfied by estimating the elevation to an accuracy of one half of the contour interval. All points less than one fourth of the distance between the lines are considered to be at an elevation of one half of the contour interval above the lower line (fig. 5-6).

To estimate the elevation of the top of an unmarked hill, add half of the contour interval to the elevation of the highest contour line around the hill.

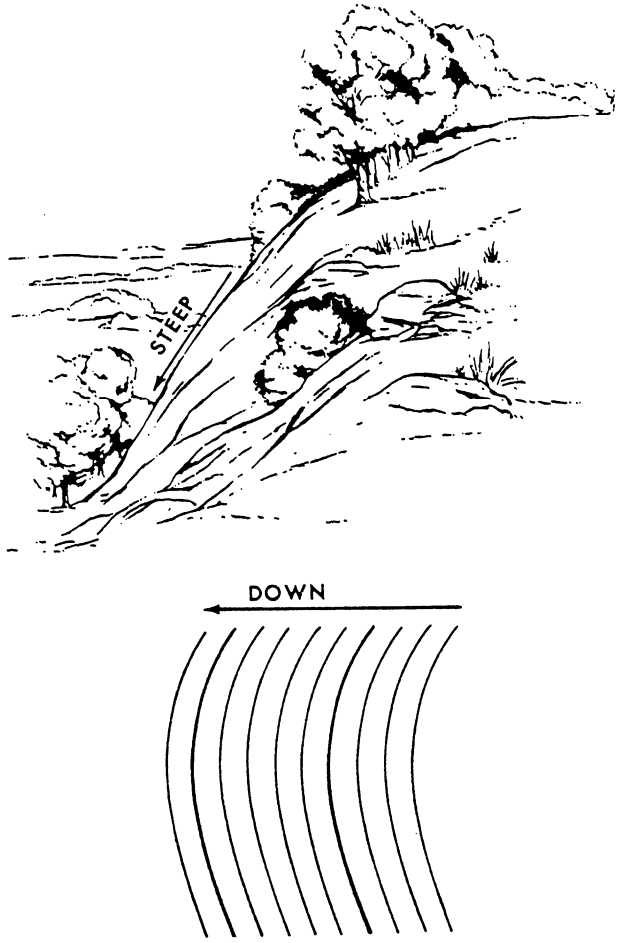

Figure 5-8.—Uniform, steep slope.

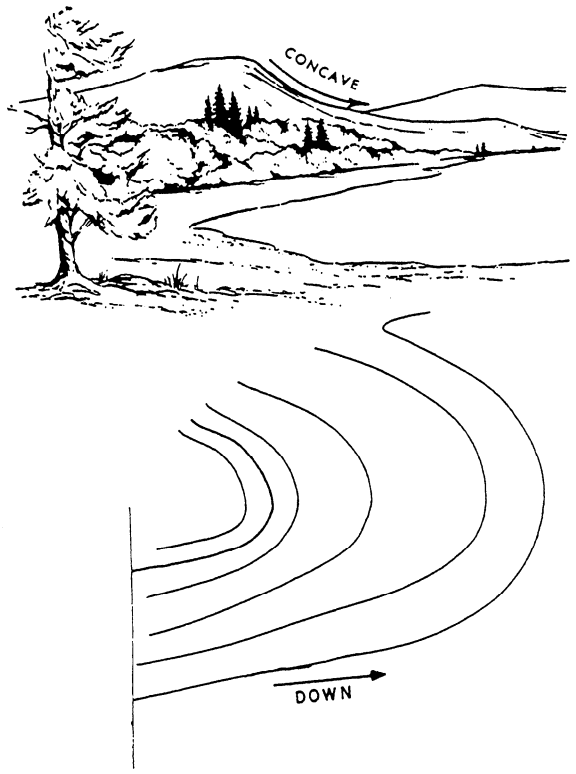

Figure 5-9.—Concave slope.

To estimate the elevation of the bottom of a depression, subtract half of the contour interval from the value of the lowest contour around the depression.

On some maps, the index and intermediate contour lines do not show the elevation and relief in as much detail as may be needed; then SUPPLEMENTARY CONTOURS may be used. These contour lines are dashed brown lines, usually at one half of the contour interval for the map. A note in the marginal information indicates the interval used. They are used exactly like solid contour lines.

On some maps, the contour lines may not meet the standards of accuracy but are sufficiently accurate in both value and interval to be shown as contours rather than as form lines. On maps of this type, the contours are considered as approximate and are shown with a dashed symbol; elevation values are given at intervals along the heavier (index contour) dashed lines. The contour note in the map margin identifies them as approximate contours.

In addition to the contour lines, bench marks and spot elevations are used to indicate points of known elevation on the map. BENCH MARKS, the more accurate of the two, are symbolized by a black X, for example, XBM 124. The elevation value shown in black refers to the center of the X. SPOT ELEVATIONS, shown in brown, generally are located at road junctions, on hilltops, and other prominent landforms. The symbol ^P^P designates an accurate horizontal control point. When a bench mark and a horizontal control point are located at the same point, the symbol BM^P^P^P is used.

The spacing of the contour lines indicates the nature of the slope. Contour lines evenly spaced and wide apart indicate a uniform, gentle slope (fig. 5-7). Contour lines evenly spaced and close together indicate a uniform, steep slope. The closer the contour lines are to each other, the steeper the slope (fig. 5-8).

Contour lines closely spaced at the top and widely spaced at the bottom indicate a concave slope (fig. 5-9). Considering relief only, an observer at the top of a concave slope can observe the entire slope and the

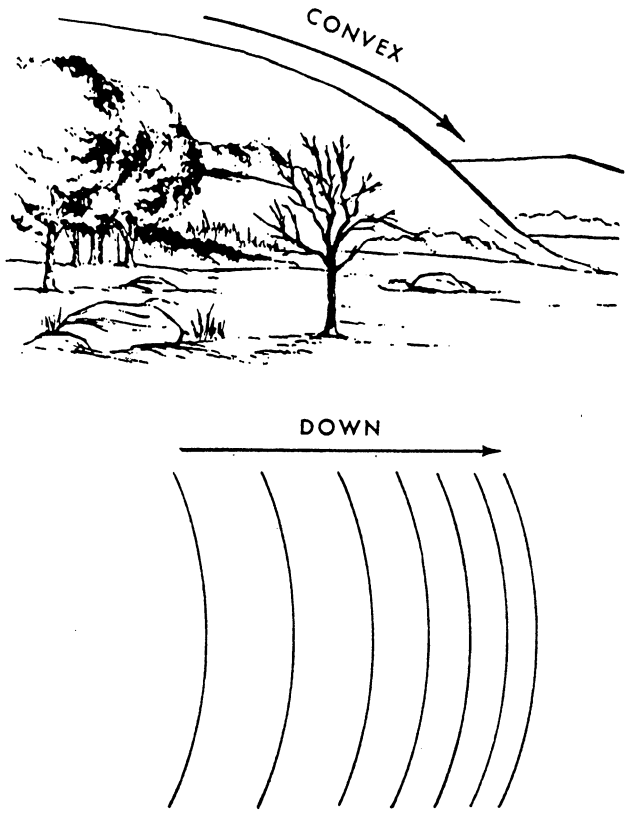

Figure 5-10.—Convex slope.

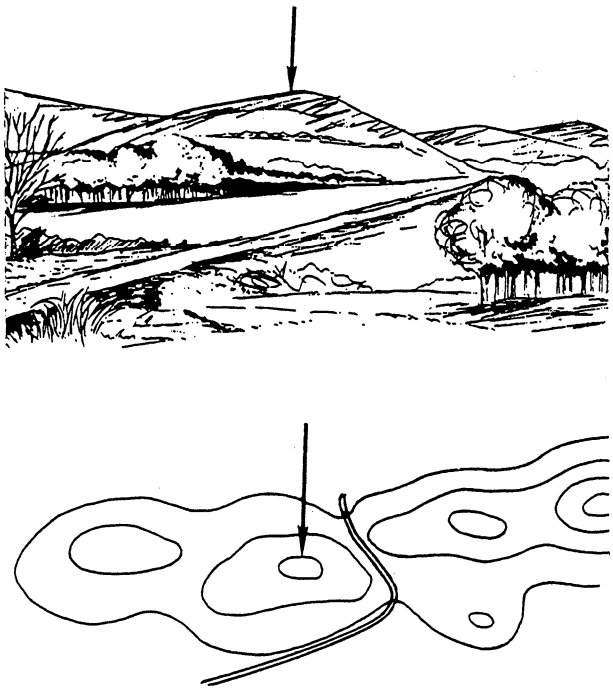

Figure 5-11.—Hill.

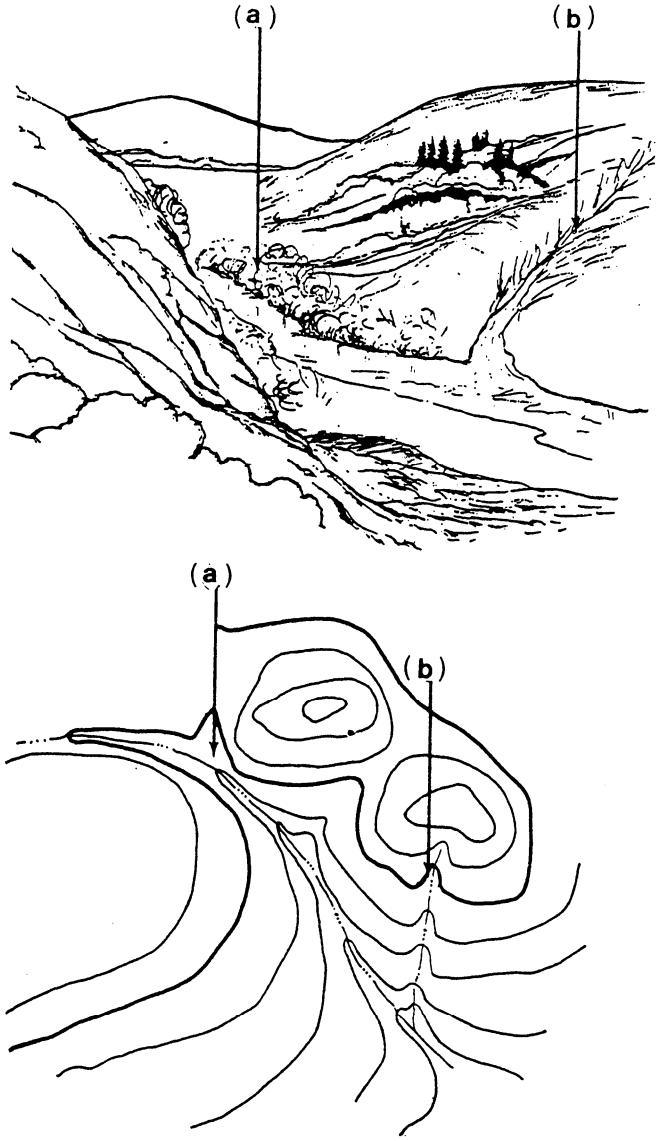

Figure 5-12.—(a) Valley; (b) Draw.

terrain at the bottom. However, a unit attacking up a concave slope would have no cover or concealment from observers or weapons at or near the top; also, farther up the slope, the climb would be more difficult.

Contour lines widely spaced at the top and closely spaced at the bottom indicate a convex slope (fig. 5-10). An observer at the top of a convex slope would have no observation of most of the slope or of the terrain at the bottom. But a unit attacking up a concave slope would have a much greater degree of cover and concealment than on a concave slope; also, the climb farther up the slope would be easier.

In order to show the relationship of land formations to each other and how they would be symbolized on a

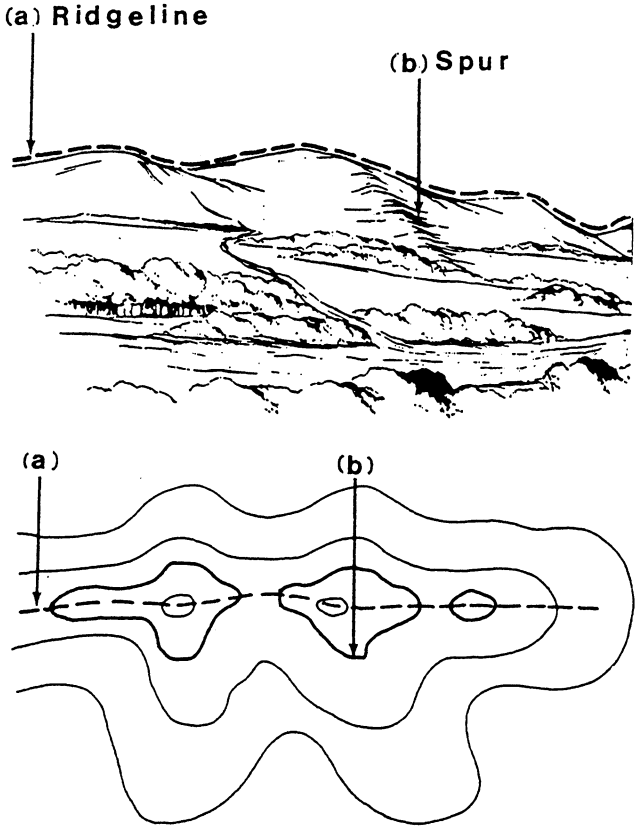

Figure 5-13.—(a) Ridge; (b) Spur.

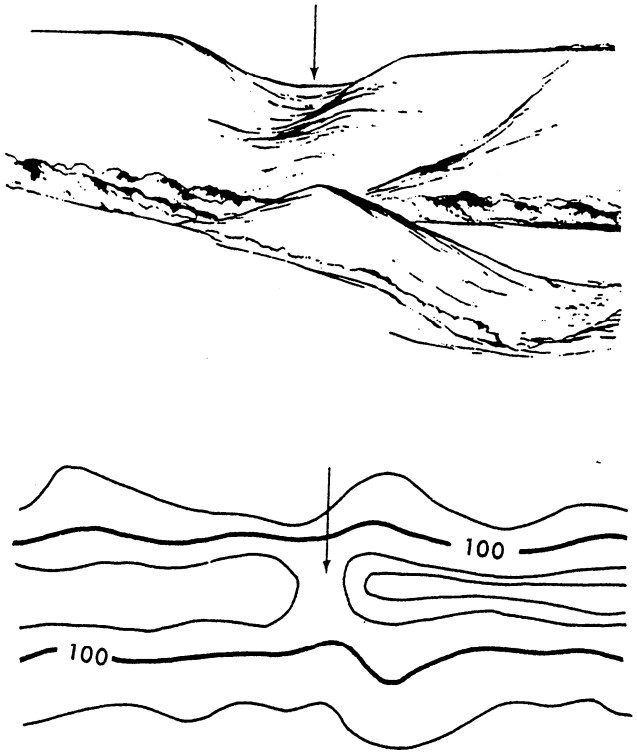

Figure 5-14.—Saddle.

contour map, stylized panoramic sketches of the major relief formations are drawn. Then a contour map of each sketch is developed. Each of the figures that follow shows a sketch and a map with a different relief feature and its characteristic contour pattern.

1. HILL. This is a point or small area of high ground (fig. 5-11). When you are located on a hilltop, the ground slopes down in all directions.

2. VALLEY. A valley is a course of a stream that has at least a limited extent of reasonably level ground bordered on the sides by higher ground. (See fig. 5-12, views A and B, top and bottom.) The valley generally has maneuvering room within its confines. Contours indicating a valley are U-shaped and tend to parallel a major stream before crossing it. The more gradual the fall of a stream, the farther each contour parallels it. The curve of the contour crossing always points upstream.

3. DRAW. A draw is a less developed course of a stream in which there is essentially no level ground and, therefore, little or no maneuvering room within its confines. (See fig. 5-12, views A and B, top and bottom.) The ground slopes upward on each side and toward the head of the draw. Draws occur frequently along the sides of ridges at right angles to the valleys between them. Contours indicating a draw are V-shaped, with the point of the V toward the head of the draw.

4. RIDGE. Normally, a ridge is a line of high ground with minor variations along its crest. (See fig. 5-13, views A and B, top and bottom.) The ridge is not simply a line of hills; all points of the ridge crest are appreciable y higher than the ground on both sides of the ridge.

5. SPUR. A spur is a short, continuously sloping line of higher ground normally jutting out from the side of a ridge. (See fig. 5-13, views A and B, top and bottom.) A spur is often formed by two roughly parrallel streams cutting draws down the side of a ridge.

6. SADDLE. A saddle is a dip or low point along the crest of a ridge. A saddle is not necessarily the lower ground between two hilltops; it maybe simply a dip or break along an otherwise level ridge crest (fig. 5-14).

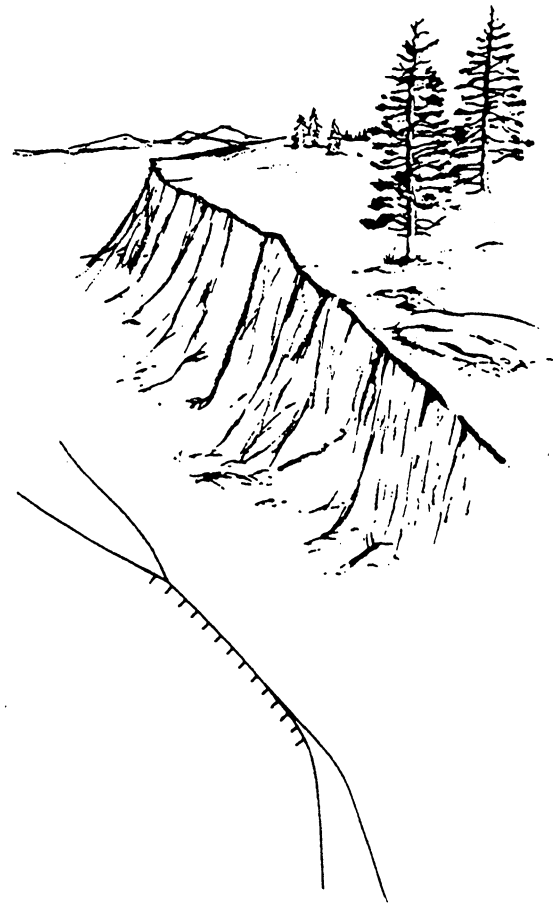

Figure 5-15.—Cliff.

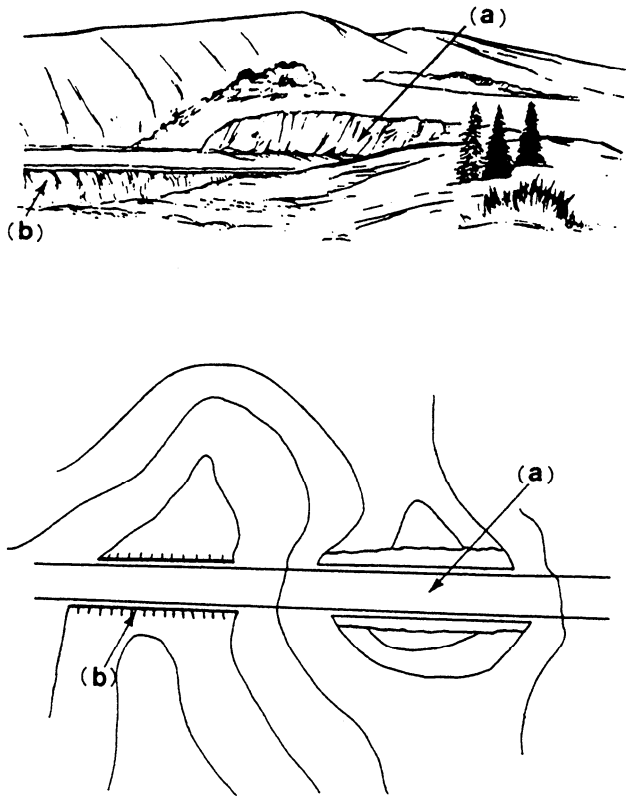

Figure 5-16.—(a) Cut; (b) Fill.

7. CLIFF. A cliff is a vertical or near vertical slope (fig. 5-15). When a slope is so steep that it cannot be shown at the contour interval without the contours coming together, it is shown by a ticked "carrying" contour or contours. The ticks always point toward lower ground.

8. CUTS and FILLS. Cuts and falls are man-made features caused when the bed of a road or railroad is graded or leveled by cutting through high areas and filling in low areas along the right-of-way. (See fig. 5-16, views A and B, top and bottom.)

9. DEPRESSION. A depression is a low point or a sinkhole, surrounded on all sides by higher ground (fig. 5-17).

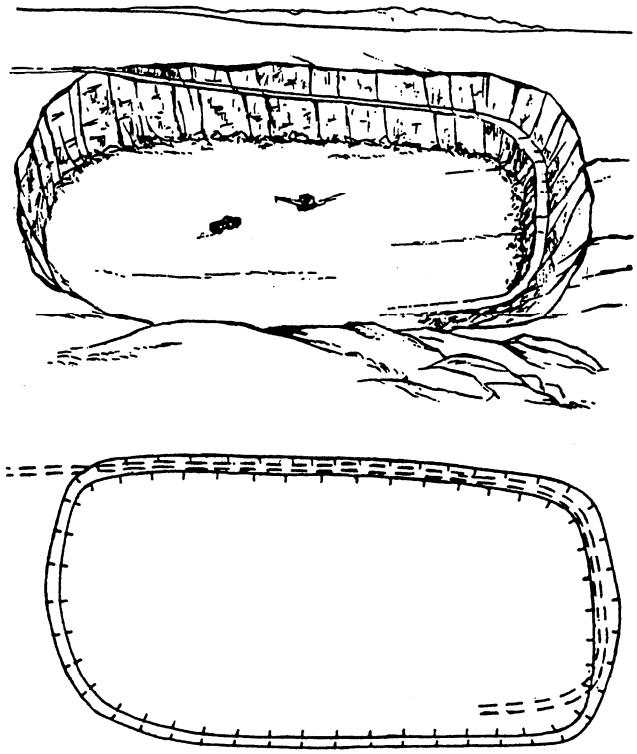

Figure 5-17.—Depression.

Slope

The rate of rise or fall of a landform is known as its slope and may be described as being gentle or steep. The question arises as to how gentle or how steep? The speed at which equipment or personnel can move is

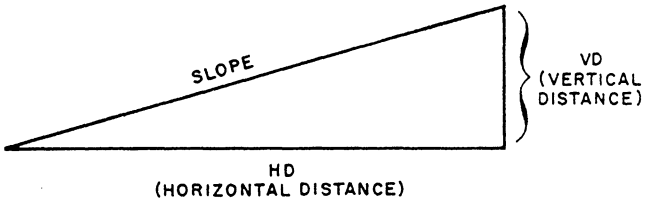

Figure 5-18.–Slope diagram.

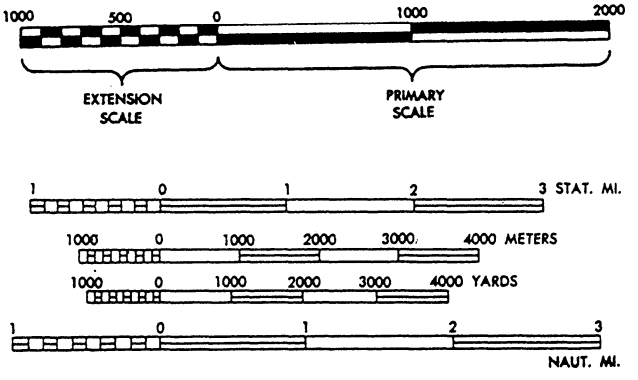

Figure 5-19.—Graphic scale.

affected by the slope of the ground. Most equipment has a limit on the steepness of slope it can negotiate. So a more exact way of describing a slope is demanded. Slope may be expressed in several ways, but all of them depend upon a comparison of vertical distance (VD) to horizontal distance (HD) (fig. 5-18). VD is the difference between the highest and lowest elevations of the slope and is determined from the contour lines. HD is the horizontal ground distance between the highest and the lowest elevations of the slope.

The VD and HD must be expressed in the same units. Both measurements must be made with extreme accuracy in order to have a valid determination of steepness. The computations normally are made for only the steepest part of a slope.

Scale and Distance

A map is a graphic representation of an area and, therefore, is not made to full scale (actual size). Since it is not full size, some means of measuring the distance from one point on the map to another is necessary. This is done with the aid of a scale.

There are two types of scales in general use on military maps. The first is called a graphic scale and is

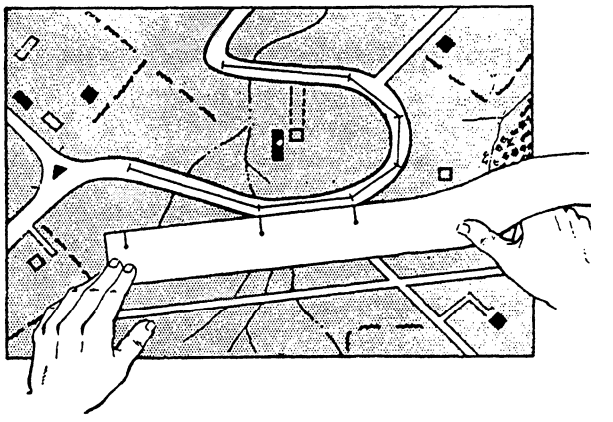

Figure 5-20.—Measuring curved line distance on a map.

indicated by a special scale legend that is printed on the map. The second type of scale is the ratio between the horizontal distance on the map and the corresponding distance on the ground.

The GRAPHIC SCALE that is printed on your map is especially made for that map and should not be used on any other map. Figure 5-19 shows a typical graphic scale. To the right of the zero (0), the scale is marked in full units of measure and is called the PRIMARY SCALE. The part to the left is zero (0) and is divided into tenths of a unit and is called the EXTENSION SCALE. Most maps have three or more graphic scales, each of which indicates distance in a different unit of measure. To determine the straight-line distance between two points on a map, use the following steps:

1. Lay the straightedge of a piece of paper on the map so the edge of the paper touches both points.

2. Make a mark on the edge of the paper at each point.

3. Move the paper down to the graphic scale, and from the scale, read the ground distance between the points. Be sure to use the scale that indicates the unit of measure desired.

To measure distance along a winding road, stream, or other curved line, the straightedge of a piece of paper should be used again.

1. Make a mark at or near one end of the paper and place it at the point from which the line is to be measured, as shown in figure 5-20.

2. Align the edge of the paper along a straight portion, and make a tick mark on both the map and the paper at the end of the aligned portion

3. Keeping both tick marks together, place the point of the pencil on the tick mark of the paper to hold it in place. Pivot the paper until another straight portion is aligned and make another mark on both map and paper.

4. Continue in this manner until the measurement is complete. Then place the paper on the graphic scale and read the ground distance.

The RATIO-TYPE SCALE is simply a comparison between a given distance measured on the map and on the ground. It is independent of any unit of measure. A scale of 1/25,000 means that one unit of measure on the map is equal to 25,000 of the same units of measure on the ground. The ground distance between two points may be determined by measuring between the points on the map and multiplying the map measurement by the scale. For example, the distance between two bridges on a certain map is 15 inches. The scale of the map is 1:50,000. Therefore, the actual distance on the ground is found by multiplying 15 inches by 50,000 (15 times 50,000 equals 750,000 inches). If this is to mean anything to you, change it to units that can be easily pictured in your mind. These units might be feet, yards, meters, kilometers, or miles. To change the 750,000 inches to feet, you need to divide by 12 (the number of inches in a foot); hence 750,000 divided by 12 equals 62,500 feet. To change the 62,500 feet to miles, divide again by 5,280 (the number of feet per mile); thus 62,500 divided by 5,280 equals 11.8 miles.

By using either of the methods described above, you can determine the distance between any two points.

Direction

Directions are expressed in everyday life as right, left, straight ahead, and so forth. But the question arises, To the right of what? Military personnel require a method of expressing a direction that is accurate, adaptable for use in any area of the world, and has a common unit of measure.

Directions are expressed as units of angular measure, and there are several systems used.

1. The most commonly used unit of angular measure is the degree with its subdivisions of minutes and seconds.

2. Another unit, less frequently used, is the mil (abbreviated m). For the U.S. military Purposes, a complete circle is divided into 6,400 mils. The mil is commonly used in artillery, tank, and mortar gunnery. It is convenient for many practical uses because it is approximately one unit of length at a distance (range) of one thousand units.

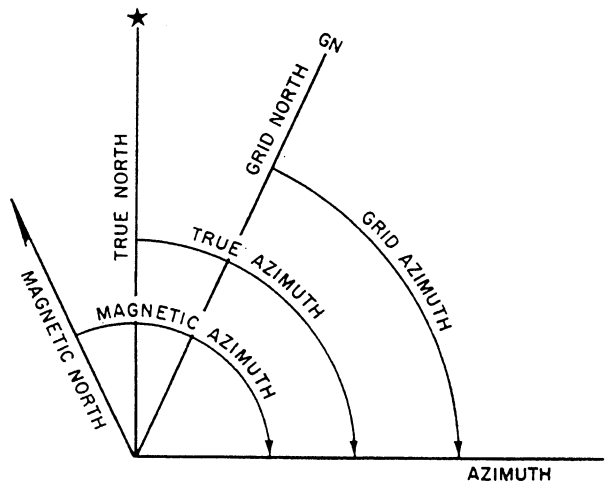

Figure 5-21.—True, magnetic, and grid azimuths.

Base Line

In order to measure anything, there must always be a starting point, or zero measurement. To express a direction as a unit of angular measure, there must be a starting point, or zero measure, and a point of reference. These two points designate the base, or reference, line. There are three base lines–true north, magnetic north, and grid north. Those most commonly used are magnetic and grid; the magnetic when working with a compass, and the grid when working with a military map.

TRUE NORTH. This is a line from any position on the surface of the earth to the North Pole. All lines of longitude are true north lines. True north is usually symbolized by a star (fig. 5-21).

MAGNETIC NORTH. The direction to the magnetic North Pole is indicated by the north-seeking needle of a magnetic instrument. Magnetic north is usually symbolized by a half arrowhead (fig. 5-21).

GRID NORTH. This is the north established by the vertical grid lines on the map. Grid north may be symbolized by the letters *GN* (fig. 5-21).

Topographic Map Symbols

The purpose of a topographic map is to permit you to visualize an area of the surface of the earth with

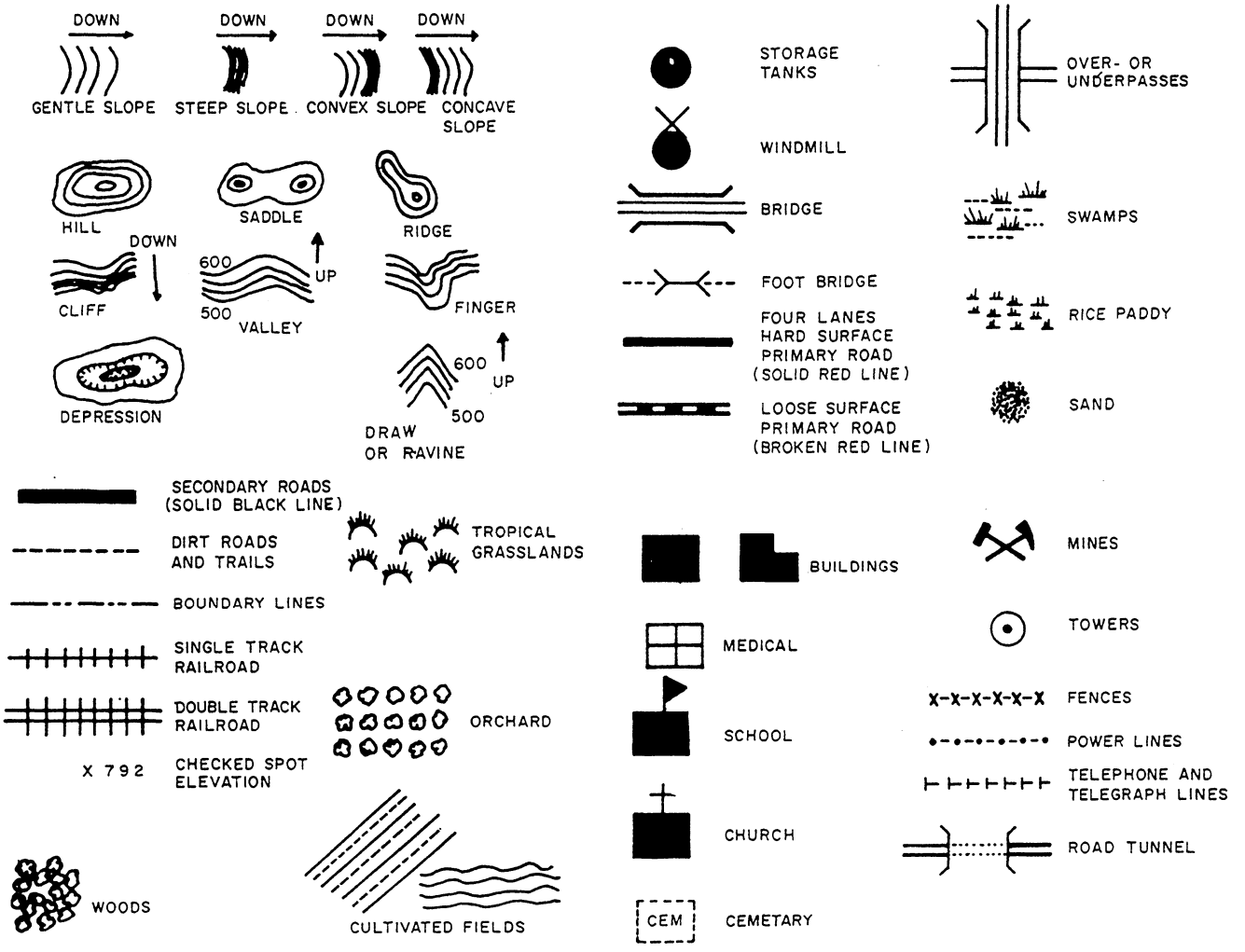

Figure 5-22.—Topographic symbols.

pertinent features properly positioned. Ideally, all features within an area would appear on the map in their true proportion, position, and shape. However, this is not practical. Many of the features would be-unimportant and others could not be recognized because of their reduction in size. Therefore, the map maker has been forced to use symbols to represent these features. These symbols resemble, as closely as possible, the actual features themselves. (See fig. 5-22.)

Topographic symbols are usually printed in a number of standardized colors. This is done so the features on the map are easier to identify and to give them a more natural appearance and contrast.

Black–the majority of cultural or man-made features

Blue–water features, such as lakes, rivers, and swamps

Green–vegetation, such as woods, orchards, or vineyards

Brown–all relief features, such as contours

Red–main roads, built up areas, and special features

Others–occasionally used to show special information; generally, explained in the marginal notes

Military Symbols

In addition to topographic symbols used to represent natural and man-made features of the earth, the military establishment requires some method for showing the identity, strength, locations, and movements of its troops, activities, and installations. The symbols used to represent these features are known as military symbols. As these features are constantly changing and moving, they are not normally printed on the maps. They appear on special maps and overlays and are handled by

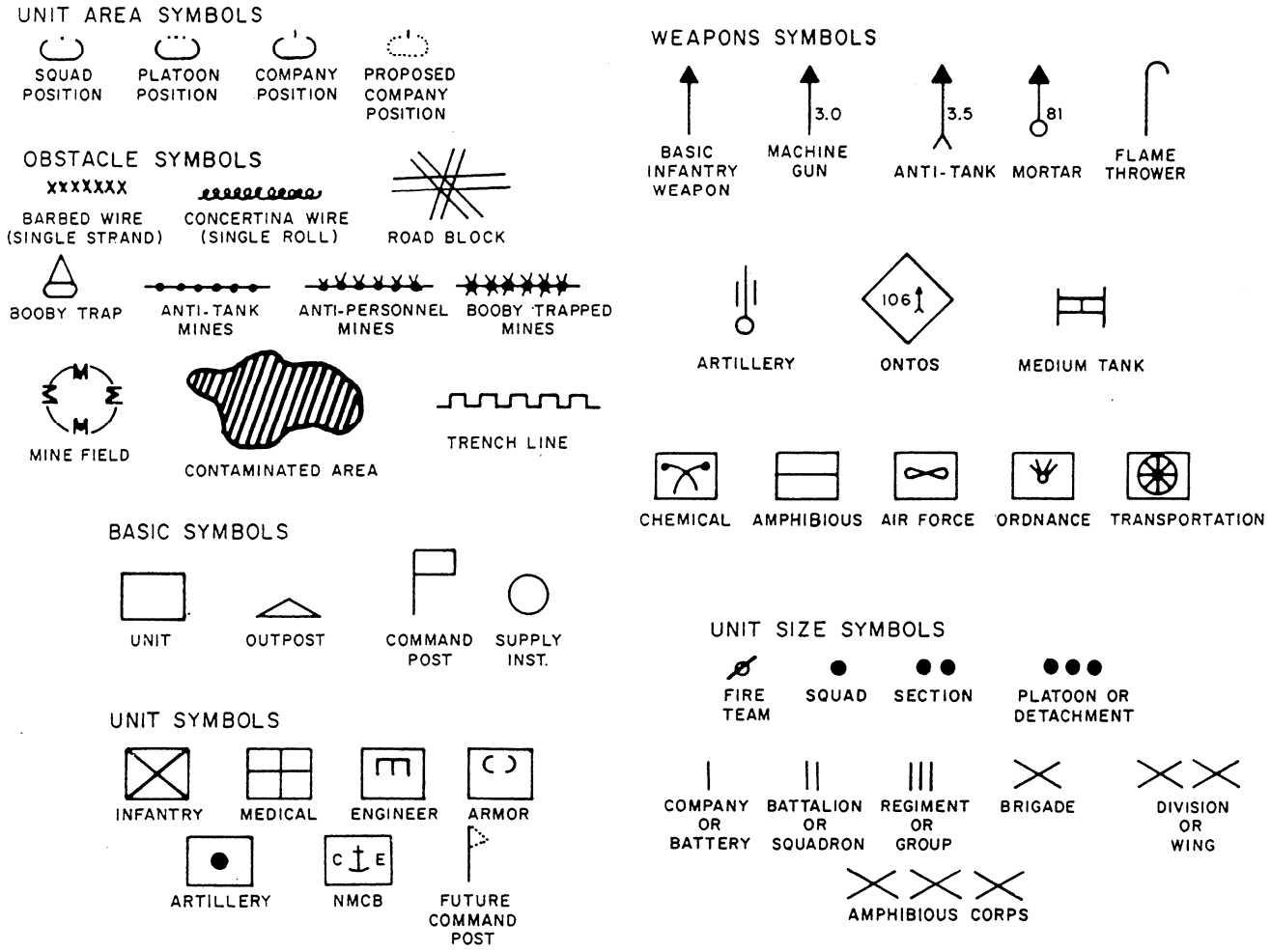

Figure 5-23.—Typical military symbols.

following proper security precautions. Figure 5-23 shows many of these symbols.

Care of Maps

One of the first precautions in caring for maps is folding the map properly. Figures 5-24 and 5-25 show ways of folding maps to make them small enough to be carried easily and still be available for use without having to unfold them entirely.

Your maps may have to last a long time, so protect them as best you can. Whenever possible, carry a map in a waterproof packet, in a pocket, under an outer garment, or other place where it is handy but still protected.

In marking a map, use light lines that maybe erased easily without smearing, smudging, or leaving marks that may later tend to confuse someone. If you must trim the margins of a map for any reason, be careful to copy any marginal information that may be needed later, such

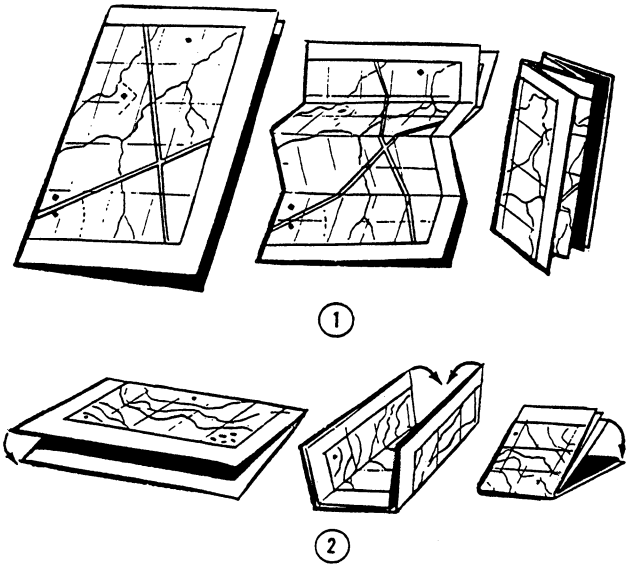

Figure 5-24.—Two methods of folding a map.

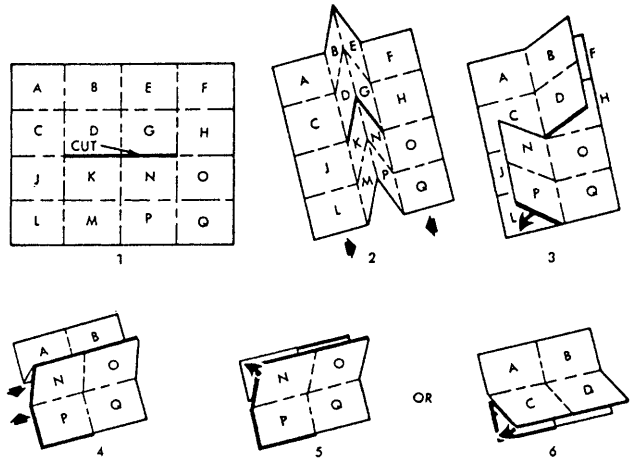

Figure 5-25.—How to slit and fold.

as grid and magnetic declination data or overlapping grid values and ticks.

LENSATIC COMPASS

The lensatic compass is the most commonly used and simplest instrument for measuring directions and angles in the field. Two varieties of magnetic compasses are standard for military use today: the lensatic compass (fig. 5-26) and the artillery (M2) compass. Since the M2 is a special-purpose compass, it is not discussed in this chapter.

In order to use a map effectively in the field for purposes of identification, location, or reporting, you must orient, or align, the map with the ground. A map is oriented when, in a horizontal position, its north points to the north and all map lines are parallel to their corresponding lines on the ground. A map user is oriented when he knows his position on the oriented map.

A fast and accurate way to orient a map is with a lensatic compass. When a compass rose (picture of a compass card) appears on the map, place the map on a flat surface and draw the magnetic north line. Open the compass and place it over the magnetic north line so the sight points toward the top of the map and is directly over the magnetic north line that you have drawn. Turn the map, taking care not to move the compass from its position over the north line until the north arrow of the compass is aligned under the index line of the compass. The map is now oriented. For maps that do not have a compass rose, align the compass sights over a north-south grid line. Then rotate the map and compass together until the north arrow of the compass points in the same direction and amount from the grid line, shown in the declination diagram.

To orient a map when a compass is not available requires a careful examination of the map and the ground features of the area to find linear features that are common to both the map and the ground. Linear

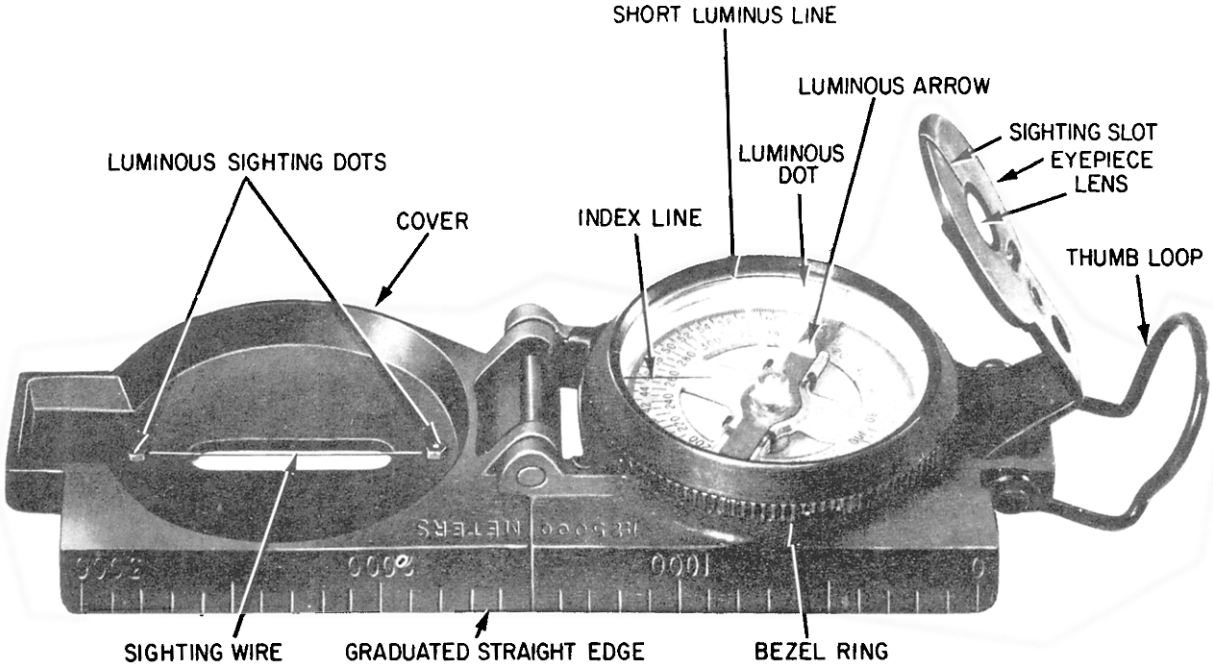

Figure 5-26.—Lensatic compass.

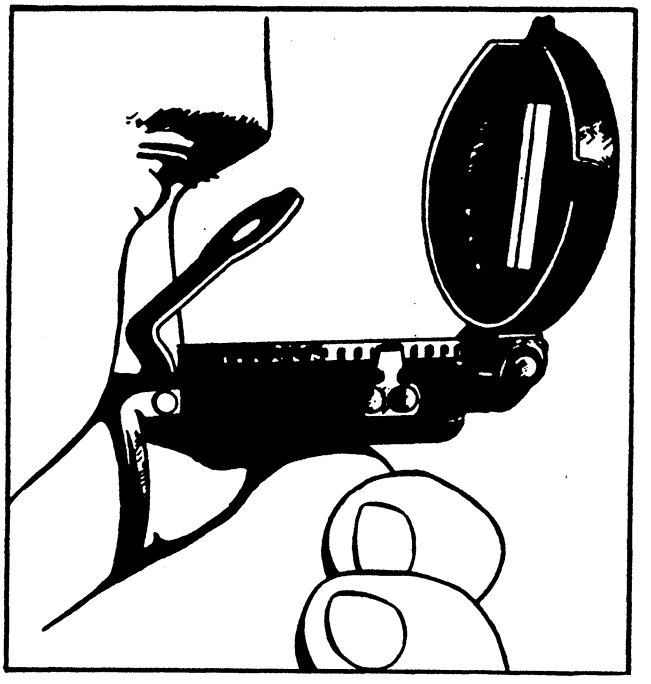

Figure 5-27.—A method of holding the compass.

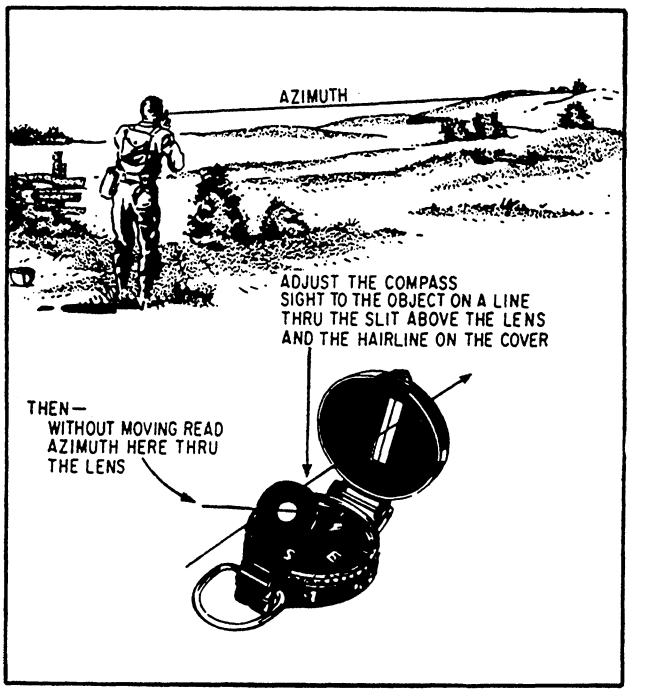

Figure 5-28.—A method of determining the azimuth of a visible object.

features are those that have length. Good examples are roads, railroads, fence lines, power lines, and so forth. By aligning the features on the map with the features on the ground, you can orient the map.

The lensatic compass must always be held level and firm when you are sighting on an objective and reading an azimuth (a horizontal angle measured in a clockwise reamer from a north base line). There are several techniques for holding the compass and sighting, but we will discuss only two methods.

To sight an objective and read an azimuth with the first method, use the following steps:

1. Open the cover of the compass so it forms a right angle with the compass. Move the eyepiece so the compass dial is visible through the lens, as shown in figure 5-27.

2. Align the slot in the eyepiece with the hairline sighting wire in the cover and with the target.

3. Read the azimuth by glancing down at the dial through the lens.

This technique provides a reading precise enough to use for "Intersection" and "Resection" (discussed later in this chapter).

The second method has an advantage because it keeps the compass lower and farther away from the steel helmet of the user; but it is less precise than the method just described.

To learn the second method, study the following steps:

1. Open the cover until it forms a straightedge with the compass base, as shown in figure 5-26.

2. Pull the eyepiece as far to the rear as possible, perpendicular to the compass base.

3. Place your thumb through the thumb loop, forming a steady base with your third and fourth fingers, and extend your index finger along the side of the compass.

4. Extend the other index finger along the remaining side of the compass and place the remaining fingers around the fingers of the other hand.

5. Pull your elbows firmly into your sides. This places the compass between your chin and your belt.

6. To take an azimuth reading, simply turn your entire body toward the object, pointing the compass cover directly at the object. (See fig. 5-28.)

7. Then just look down and read the azimuth from beneath the fixed, black index line.

For night use, special features of the compass are the luminous markings and the 3° bezel serration and

clicking device. Turning the bezel ring to the left causes an increase in azimuth, while turning it to the right causes a decrease. The bezel has a stop and spring that allows clockwise and counterclockwise turns at 3° intervals per click and holds the bezel ring in any desired position. One method for determining compass directions at night is as follows:

1. Rotate the bezel until the luminous line is over the black index line.

2. Hold the compass with the left hand and continue to rotate the bezel ring with the right hand in a counterclockwise direction for the number of clicks required. The number of clicks is determined by dividing the value of the required azimuth by 3. For example, for an azimuth of 51°, the bezel ring is rotated 17 clicks counterclockwise.

3. Turn the compass until the north arrow is directly under the luminous line on the bezel.

4. Hold the compass open and level in the palm of the left hand with the thumb along the flat side of the compass. In this manner, the compass can be held consistently in the same position. Position the compass approximately halfway between the chin and the belt, pointing directly ahead of yourself. A little practice in daylight should make you proficient in pointing the compass the same way every time. Looking directly down into the compass, turn your body until the north arrow is under the luminous line. Then move forward in the direction of the front cover luminous sighting dots (fig. 5-26).

Certain precautions about the care and use of a lensatic compass are important because they assure, within reason, that a compass works when and where you need it.

1. Handle the compass with care. The dial is set at such a delicate balance that a shock could damage the compass.

2. Close and return the compass to its special container when it is not in use. In this way, it is not only protected from possible damage but is readily available for use when needed.

3. When the compass is to be used in darkness, an initial azimuth should be set, whenever possible, while light is still available. With this initial azimuth as a base, you can read any other azimuth that is a multiple of 3° by using the clicking feature of the bezel.

4. Compass readings should NEVER be taken near visible masses of iron or electrical circuits. The following are suggested as approximate safe distances to ensure proper functioning of the compass:

High tension power lines	55 yards
Field gun, truck, or tank	18 yards
Telegraph and telephone wires and barbed wire	10 yards
Machine gun	2 yards
Helmet or rifle	0.5 yards

Nonmagnetic metals and alloys do not affect compass readings.

5. Practice by using the compass at regular intervals. This is to help you become competent in its use during an emergency.

Azimuth and Back Azimuth

The most common military method of expressing a direction is by using azimuths. As stated before, an "azimuth" is defined as a horizontal angle, measured in a clockwise reamer from a north base line. When the azimuth between two points on a map is desired, the points are joined by a straight line. Then a protractor is used to measure the angle between grid north and the drawn line. This measured angle is the grid azimuth of the drawn line (fig. 5-29). When using an azimuth, you imagine the point from which the azimuth originates as

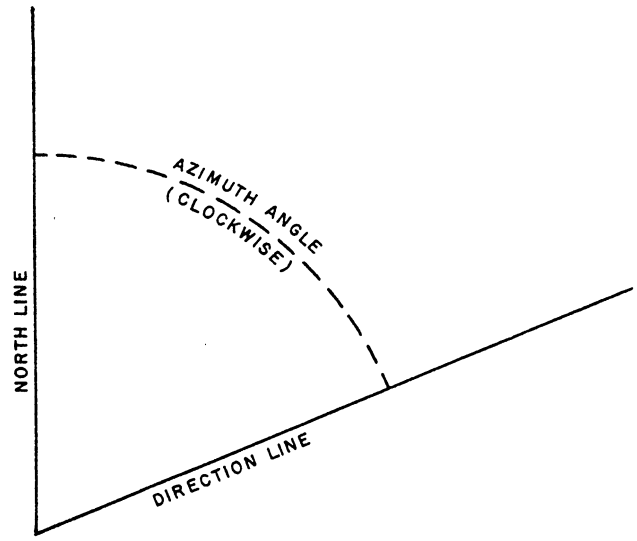

Figure 5-29.—Azimuth angle.

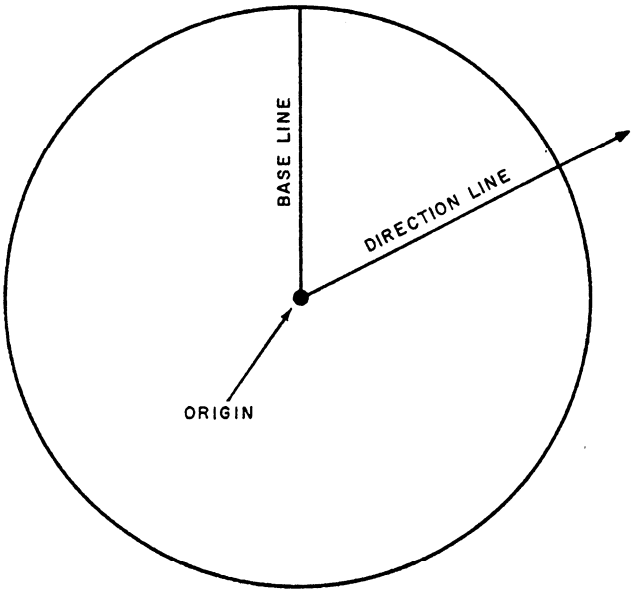

Figure 5-30.—Origin of azimuth circle.

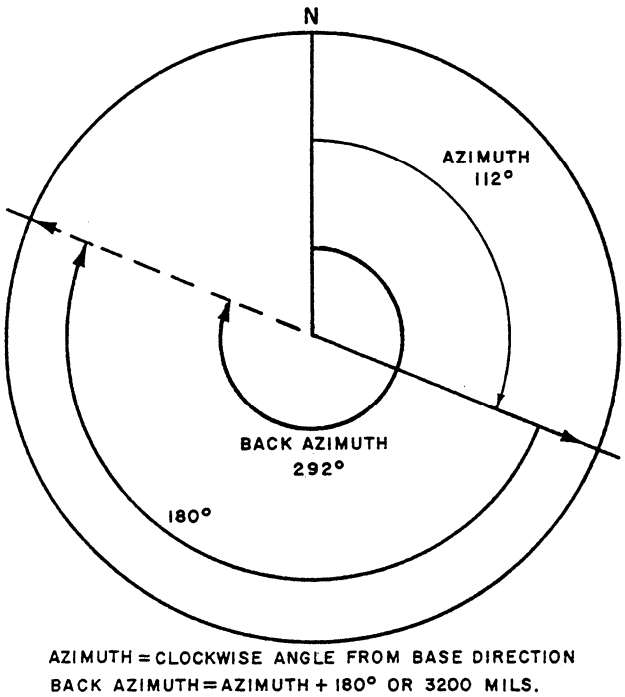

Figure 5-31.—Azimuth and back azimuth.

the center of the azimuth circle (fig. 5-30). Azimuths take their name from the base line from which they have been measured; true azimuths from true north, magnetic azimuths from magnetic north, and grid azimuths from grid north (fig. 5-21). Therefore, any one given direction can be expressed in three different ways: a grid azimuth, when measured on a military map; a magnetic azimuth, when measured by a compass; or a true azimuth, when measured from a meridian of longitude.

The BACK AZIMUTH of a line is its forward azimuth plus 180°; or if this sum is greater than 360°,

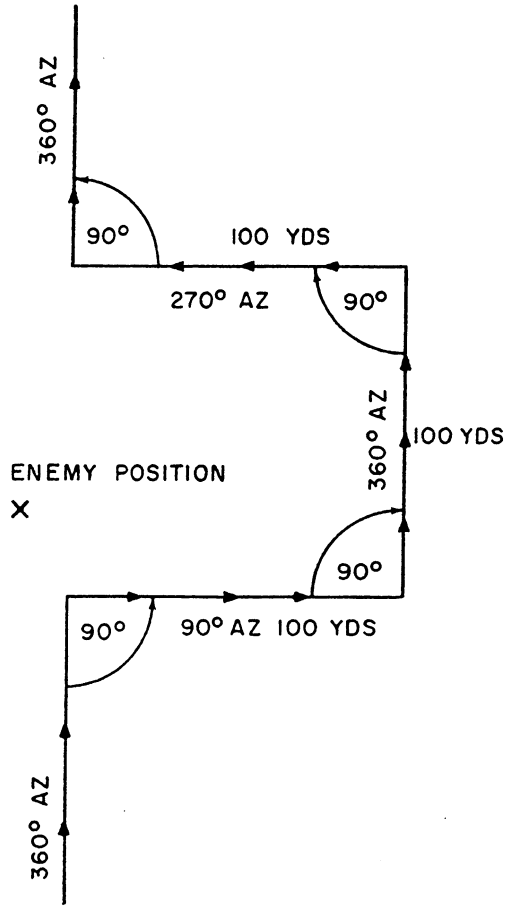

Figure 5-32.—Detour around enemy positions or obstacles.

the back azimuth is the forward azimuth minus 180°. For example, if the forward azimuth of a line is 112° (fig. 5-31), the back azimuth is as follows:

$$112° + 180° = 292°$$

When the forward azimuth of a line is 310°, the back azimuth is as follows:

$$310° - 180° = 130°$$

Figure 5-32 shows an example of how to bypass enemy positions or obstacles by detouring around them. This allows you to stay oriented by moving at right angles for specified distances. For example, if you are moving on an azimuth of 360° and wish to bypass an obstacle or position, you change direction to 90° and travel for 100 yards; change direction back to 360° and travel for 100 yards; change direction to 270° and travel for 100 yards; then change direction to 360°; and you are back on your original azimuth

Bypassing an unexpected obstacle at night is a fairly simple matter. To make a 90° turn to the right, hold the compass as described earlier in the method for night use; turn until the center of the luminous letter *E* is under the luminous line (do NOT change the setting of the

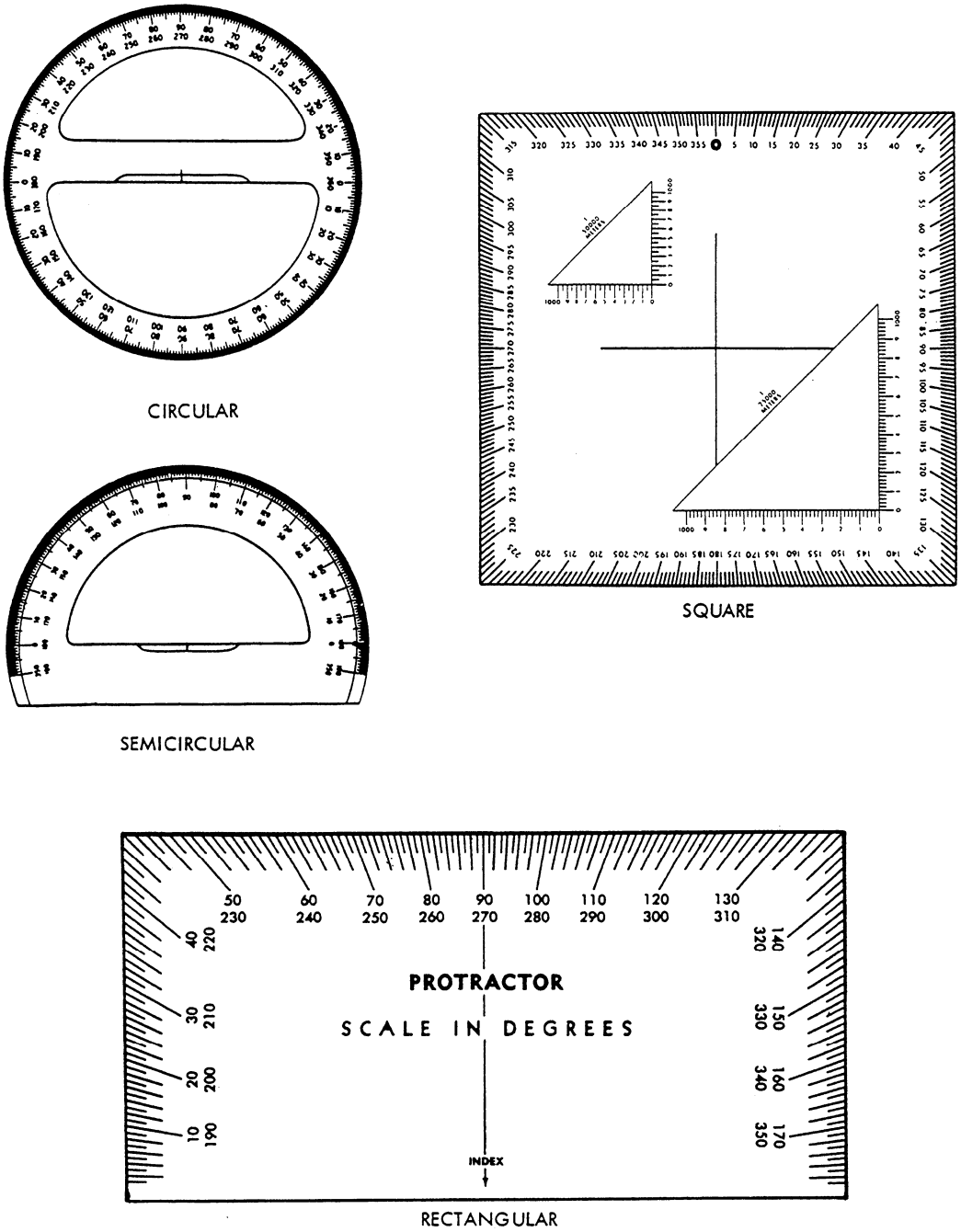

Figure 5-33.—Types of protractors.

luminous line). To make a 90° turn to the left, turn until the center of the luminous letter *W* is under the luminous line. The compass setting (bezel ring) does not require changing, and you can be sure of accurate 90° turns. For example, you decide to detour to the right. You turn until *E* **is** under the luminous line and move ahead in that direction until you have outflanked the obstacle. You then turn until the north arrow is under the luminous line and move parallel to your original course until you have bypassed the obstacle. You then turn again until the *W* is under the luminous line and move back the same distance you originally moved out. Finally, you turn until the north arrow is under the luminous line and go ahead on your original course. This method works regardless of what your initial azimuth may be.

Protractor

Protractors come in several forms–full circle, half circle, square, and rectangle (fig. 5-33). All of them

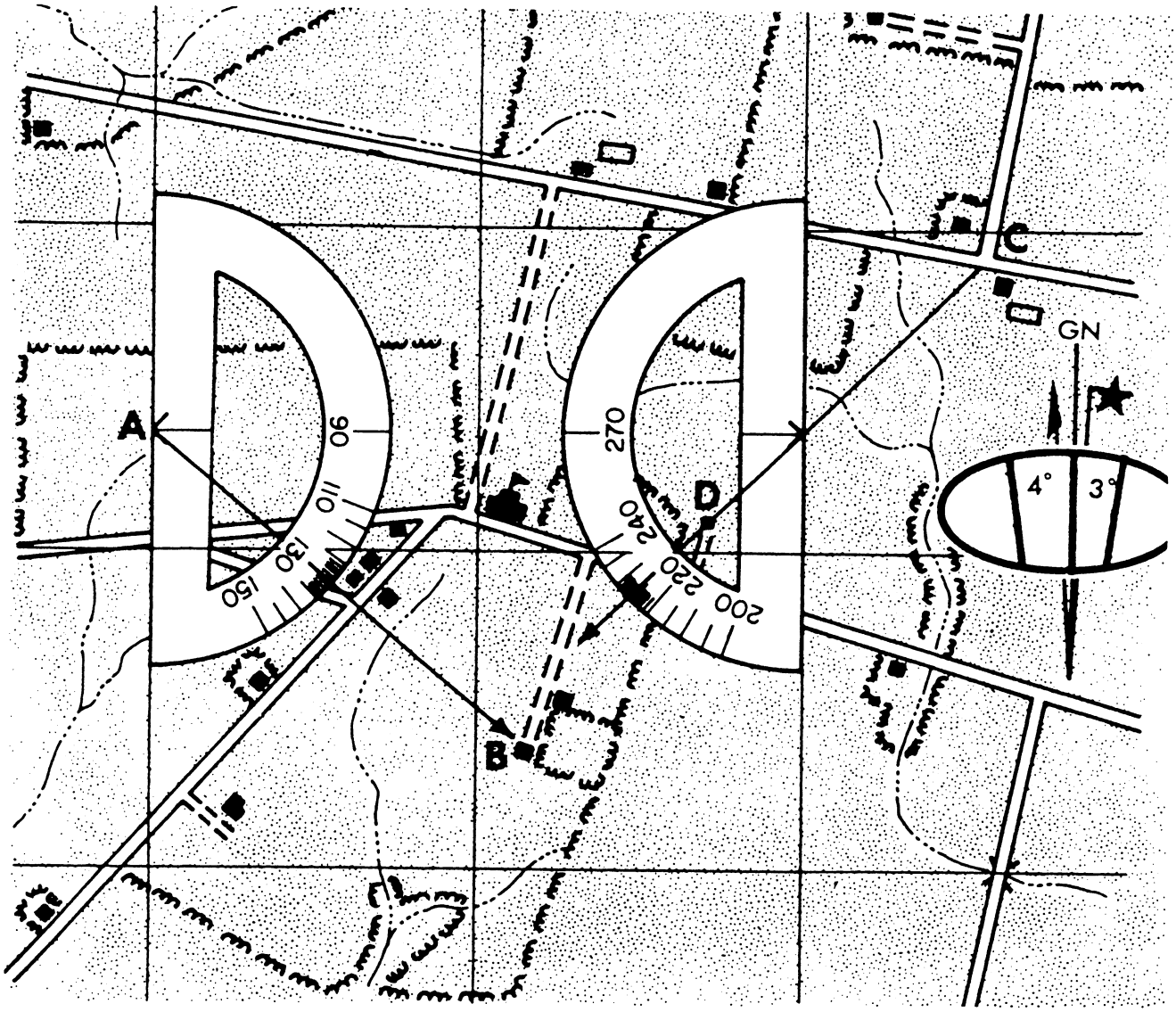

Figure 5-34.—Measuring an azimuth on a map.

divide a circle into units of angular measure; and regardless of their shape, they consist of a scale around the outer edge and an index mark The INDEX MARK is the center of the protractor circle from which all the direction lines radiate.

To determine the grid azimuth of a line from one point to another on the map (from A to B or C to D), refer to figure 5-34 as you study the following:

1. Draw a line connecting the two points.

2. Place the index of the protractor at the point where the line crosses a vertical (north-south) grid line.

3. Keeping the index at this point, align the 0°-180° line of the protractor on the vertical grid line.

4. Read the value of the angle from the scale; this is the grid azimuth of the point.

To plot a direction line from a known point on a map, refer to figure 5-35 as you study the following:

1. Convert, if necessary, the direction to azimuth.

2. Construct a north-south grid line through the known point. Then proceed in the following steps:

- First, approximately align the 0°- 180° line of the protractor in a north-south direction through the known point.

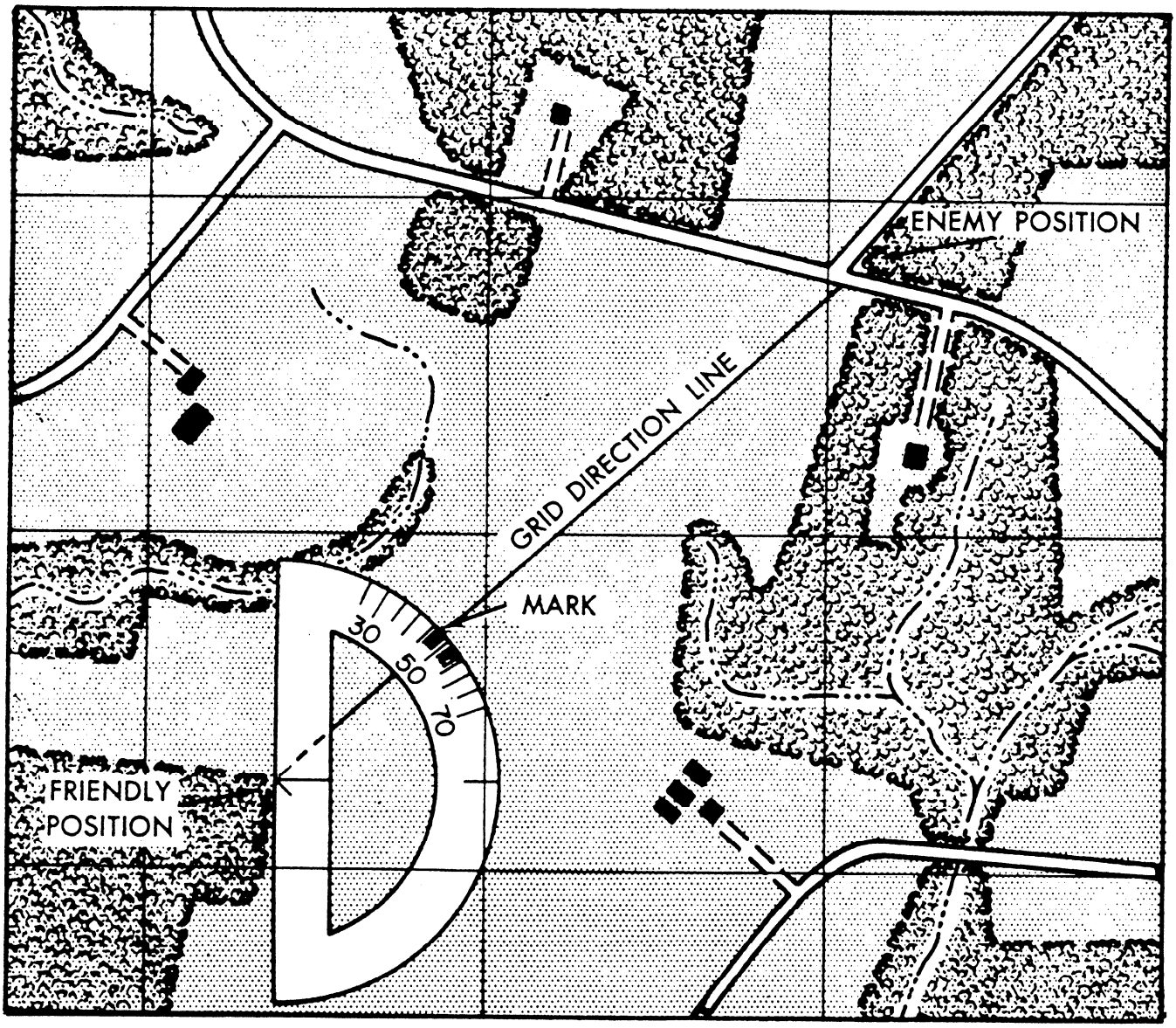

Figure 5-35.—Plotting an azimuth on a map.

- Second, holding the 0° - 180° line of the protractor on the known point, slide the protractor in the north-south direction. Slide it until the horizontal line of the protractor (connecting the protractor index and the 90° tick mark) is aligned on an east-west grid line.

- Draw a line connecting 0°, the known point, and 180°.

- Holding the 0° - 180° line coincident with this line, slide the protractor index to the known point.

- Make a mark on the map at the required angle.

- Draw a line from the known point through the mark made on the map. This is the GRID DIRECTiON line.

Intersection

Locating an unknown point by successively occupying at least two, but preferably three, known positions and sighting on the unknown point is called intersection. It is used to locate features that are not defined on the map or which are not readily identifiable. The two methods of intersection are the map and compass method and the straightedge method.

MAP AND COMPASS METHOD.— Study the following steps to locate an unknown point using the

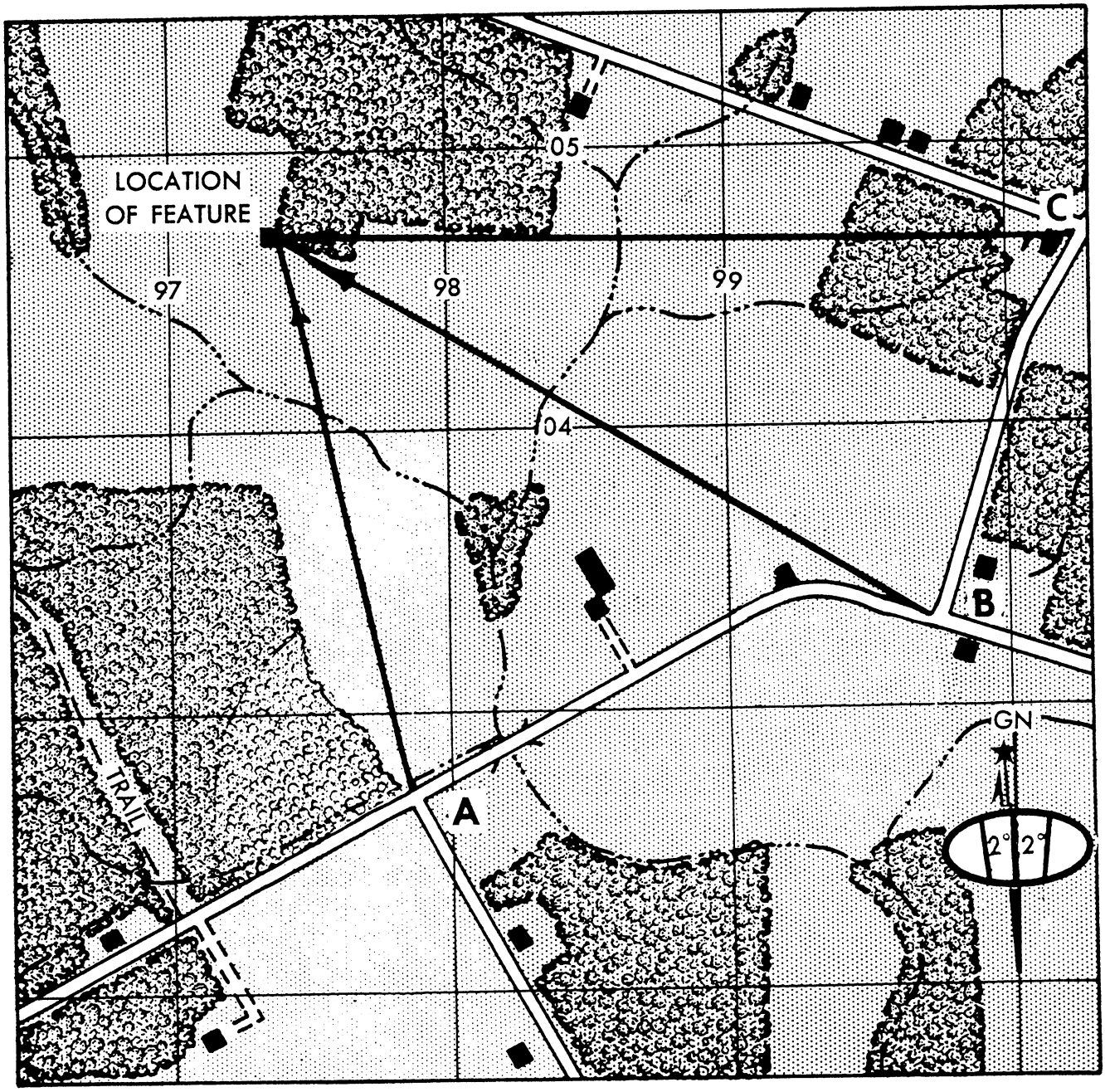

Figure 5-36.—Intersection using map and compass.

map and compass method of intersection. (See fig. 5-36.)

1. Orient the map using the compass.

2. Locate and mark your position (Point A) on the map.

3. Measure the magnetic azimuth to the unknown position; convert it to grid azimuth.

4. Draw a line on the map from your position on this grid azimuth.

5. Move to a second known position (Point B) from which the unknown point is visible. Locate this position on the map and again orient the map using the compass.

6. Repeat Steps 3 and 4 above.

7. As a check on accuracy, move to a third position (Point C) and repeat Steps 1 through 4 above.

8. The point where the lines cross is the location of the unknown position. Using three lines, you sometimes form a triangle instead of an intersection. This is called the TRIANGLE OF ERROR. If the triangle is large,

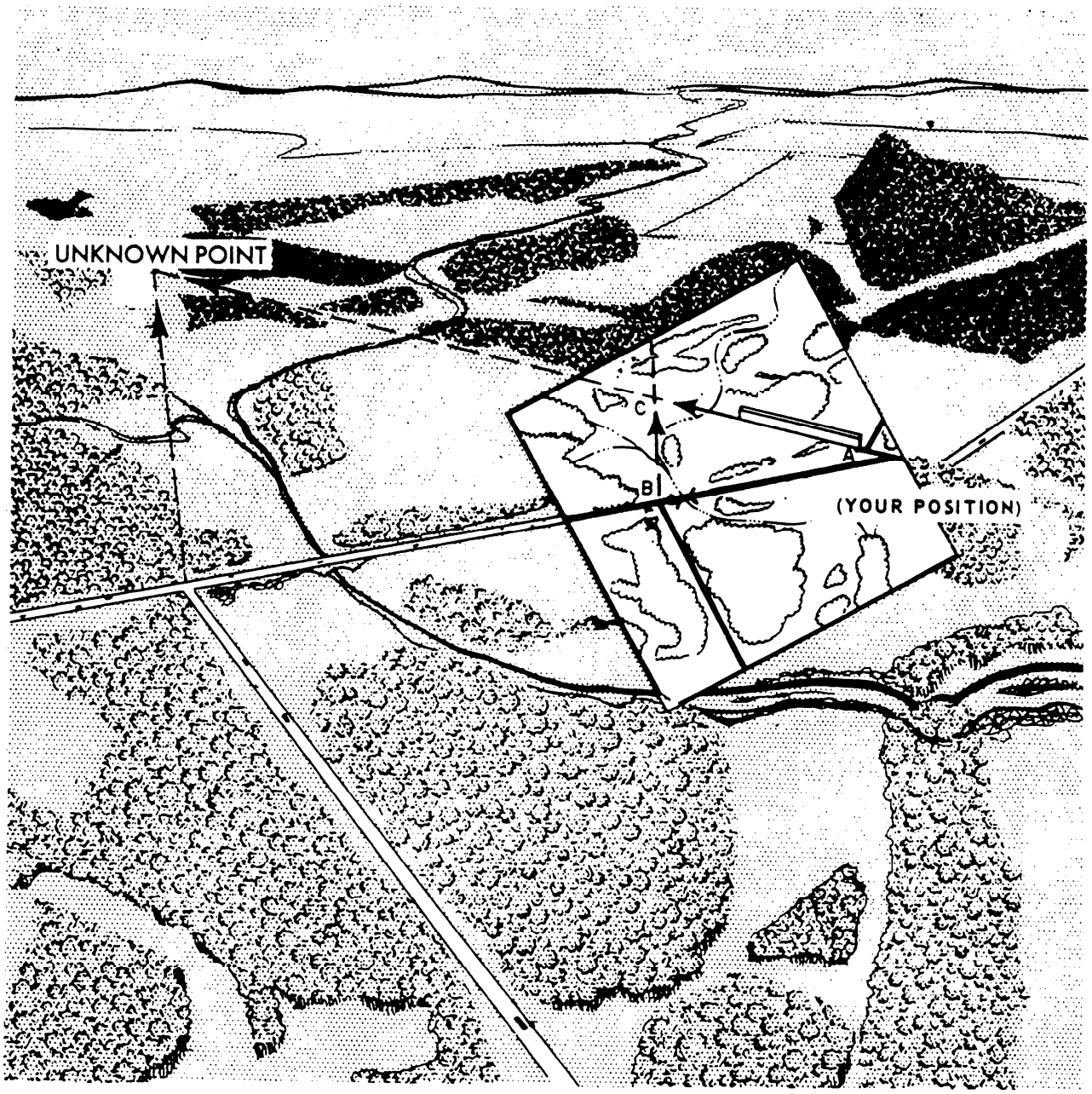

Figure 5-37.—Intersection without compass.

recheck your work to find the error. Do not assume that the position is at the center of the triangle.

STRAIGHTEDGE METHOD (WHEN NO COMPASS IS AVAILABLE).— Study the following steps to locate an unknown point using the straightedge method of intersection. (See fig. 5-37.)

1. Orient the map on a flat surface by the inspection method.

2. Locate and mark your position on the map.

3. Lay a straightedge on the map and place one end at the position of the user (Point A) as a pivot point. Then rotate the straightedge until the unknown point is sighted along the edge.

4. Draw a line along the straightedge.

5. Repeat the above procedures at Point B, and for a check on accuracy, at a third position.

6. The intersection of the lines is the location of unknown Point C.

Resection

Locating the unknown position of the user by sighting on two or three known features is called

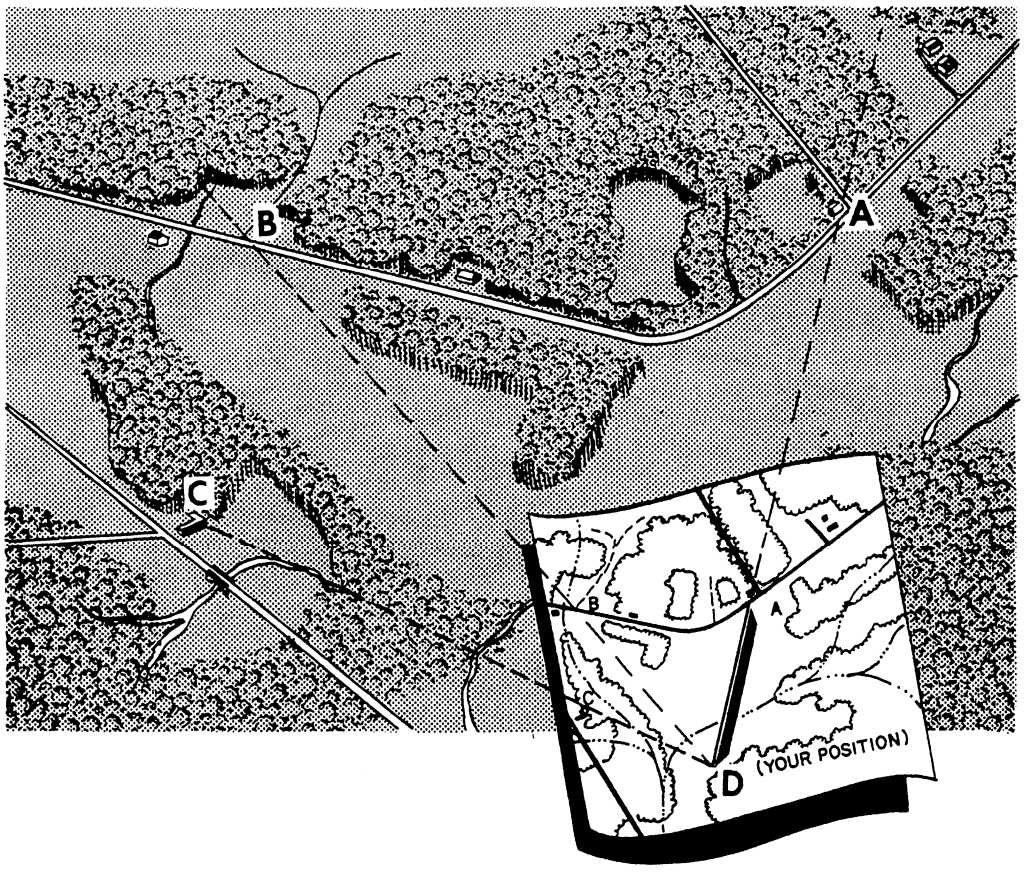

Figure 5-38.—Resection.

resection (fig. 5-38). Resection can be done with or without a compass.

MAP AND COMPASS METHOD.— Study the following steps to locate the unknown position of the user by the map and compass method:

1. Orient the map using the compass.

2. Locate two or three known positions on the ground and mark them on the map.

3. Measure the magnetic azimuth to a known position; convert it to grid azimuth.

4. Change the grid azimuth to a back azimuth and draw a line on the map from the known position back toward your unknown position.

5. Repeat Steps 3 and 4 above for a second known position.

6. For a check on your accuracy, repeat Steps 3 and 4 above for a third known position.

7. The intersection of the lines is your location. Using three lines, a triangle of error maybe formed. If the triangle is large, recheck your work.

STRAIGHTEDGE METHOD.— Study the following steps to locate the unknown position of the user by the straightedge method:

1. Orient the map on a flat surface by the inspection method.

2. Locate two or three known positions on the ground and mark them on the map.

3. Lay a straightedge on the map with the center of the straightedge at a known position as a pivot point. Rotate the straightedge until the known position on the map is aligned with the known position on the ground.

4. Draw a line along the straightedge away from the known position on the ground toward your position.

5. Repeat Step 3 above using a second known position; and as a check on your accuracy, repeat Step 3 above, using a third known position.

6. The intersection of the lines is your location.

SKETCHES AND OVERLAYS

You are not expected to be a draftsman. But you should be able, if necessary, to make rough drawings of maps, field sketches, and overlays. The instruction presented in this chapter about maps is designed to assist you in making rough drawings of them. The information below will be useful in preparing a rough drawing of a field sketch or map overlay.

The two types of sketches are panoramic and topographic.

PANORAMIC SKETCHES

A panoramic sketch is a picture of the ground or terrain. It shows the height and view from your point of observation. A panoramic sketch prepared by one scout may assist another scout in finding himself for a brief time in the same location.

To make a panoramic sketch, use the following guidance:

1. First, determine the information you desire to convey.

2. Next, draw in the landscape lines that are more or less horizontal.

3. Show the main points of the area on the sketch. Do not put in any unimportant details that might only be confusing, and do not show the foreground. Be sure you show the location of the information you are conveying.

4. Place any explanatory notes above the sketch with arrows pointing to the features explained.

5. The most prominent point in the sketch should be used as a reference point. After selecting this point, indicate the azimuth reading used to locate it.

6. Place a title on the sketch, show where it was prepared, indicate the date and the time it was made; then sign it.

TOPOGRAPHIC SKETCHES

A topographic sketch is prepared so the person receiving it can plot on a map your scouting position or the information you wish to convey. To prepare a topographic sketch, you need a map similar to one your commander has in his possession.

1. Read the azimuth from your position to the position of an object you can easily see and describe.

2. Estimate the distance, using the most accurate means available.

3. Draw the azimuth line from you to the object. Then mark the azimuth above this line and the distance below this line.

4. At the proper end of the line, indicate the object. At the other end of the line, indicate your own position.

5. Find the azimuth and the distance to some other point on the map or to the position of the command post.

6. Draw this line on the sketch. Then indicate the azimuth, the distance, and the object to which it is drawn.

7. Finally, sign the sketch.

MAP OVERLAYS

A map overlay is generally used to send back reconnaissance information. The overlay is made by placing apiece of transparent paper on a map, marking the location, and numbering the corners of the grid squares. At least two corners should be marked or crossed. These crosses are called REGISTER MARKS and are used to orient the overlay on a map later on. After the register marks have been made, you only need to write the information that is to be sent back to the command post. When the overlay is receive&it will be placed on a similar map and oriented by its register marks and the information you recorded.