

PART TWO

LAND NAVIGATION

CHAPTER 9

NAVIGATION EQUIPMENT AND METHODS

Compasses are the primary navigation tools to use when moving in an outdoor world where there is no other way to find directions. Soldiers should be thoroughly familiar with the compass and its uses. Part One of this manual discussed the techniques of map reading. To complement these techniques, a mastery of field movement techniques is essential. This chapter describes the lensatic compass and its uses, and some of the field expedient methods used to find directions when compasses are not available.

9-1. TYPES OF COMPASSES

The **lensatic compass** is the most common and simplest instrument for measuring direction. It is discussed in detail in paragraph 9-2. The **artillery M-2 compass** is a special-purpose instrument designed for accuracy; it will be discussed in Appendix G. The **wrist/pocket compass** is a small magnetic compass that can be attached to a wristwatch band. It contains a north-seeking arrow and a dial in degrees. A **protractor** can be used to determine azimuths when a compass is not available. However, it should be noted that when using the protractor on a map, only grid azimuths are obtained.

9-2. LENSATIC COMPASS

The lensatic compass (Figure 9-1, page 9-2) consists of three major parts: the cover, the base, and the lens.

a. **Cover.** The compass cover protects the floating dial. It contains the sighting wire (front sight) and two luminous sighting slots or dots used for night navigation.

b. **Base.** The body of the compass contains the following movable parts:

(1) The floating dial is mounted on a pivot so it can rotate freely when the compass is held level. Printed on the dial in luminous figures are an arrow and the letters E and W. The arrow always points to magnetic north and the letters fall at east (E) 90° and west (W) 270° on the dial. There are two scales; the outer scale denotes mils and the inner scale (normally in red) denotes degrees.

(2) Encasing the floating dial is a glass containing a fixed black index line.

(3) The bezel ring is a ratchet device that clicks when turned. It contains 120 clicks when rotated fully; each click is equal to 3°. A short luminous line that is used in conjunction with the north-seeking arrow during navigation is contained in the glass face of the bezel ring.

(4) The thumb loop is attached to the base of the compass.

c. **Lens.** The lens is used to read the dial, and it contains the rear-sight slot used in conjunction with the front for sighting on objects. The rear sight also serves as a lock and clamps the dial when closed for its protection. The rear sight must be opened more than 45° to allow the dial to float freely.

NOTE: When opened, the straightedge on the left side of the compass has a coordinate scale; the scale is 1:50,000 in newer compasses.

WARNING

Some older compasses will have a 1:25,000 scale. This scale can be used with a 1:50,000-scale map, but the values read must be halved. Check the scale.

9-3. COMPASS HANDLING

Compasses are delicate instruments and should be cared for accordingly.

a. **Inspection.** A detailed inspection is required when first obtaining and using a compass. One of the most important parts to check is the floating dial, which contains the magnetic needle. The user must also make sure the sighting wire is straight, the glass and crystal parts are not broken, the numbers on the dial are readable, and most important, that the dial does not stick.

b. **Effects of Metal and Electricity.** Metal objects and electrical sources can affect the performance of a compass. However, nonmagnetic metals and alloys do not affect compass readings. The following separation

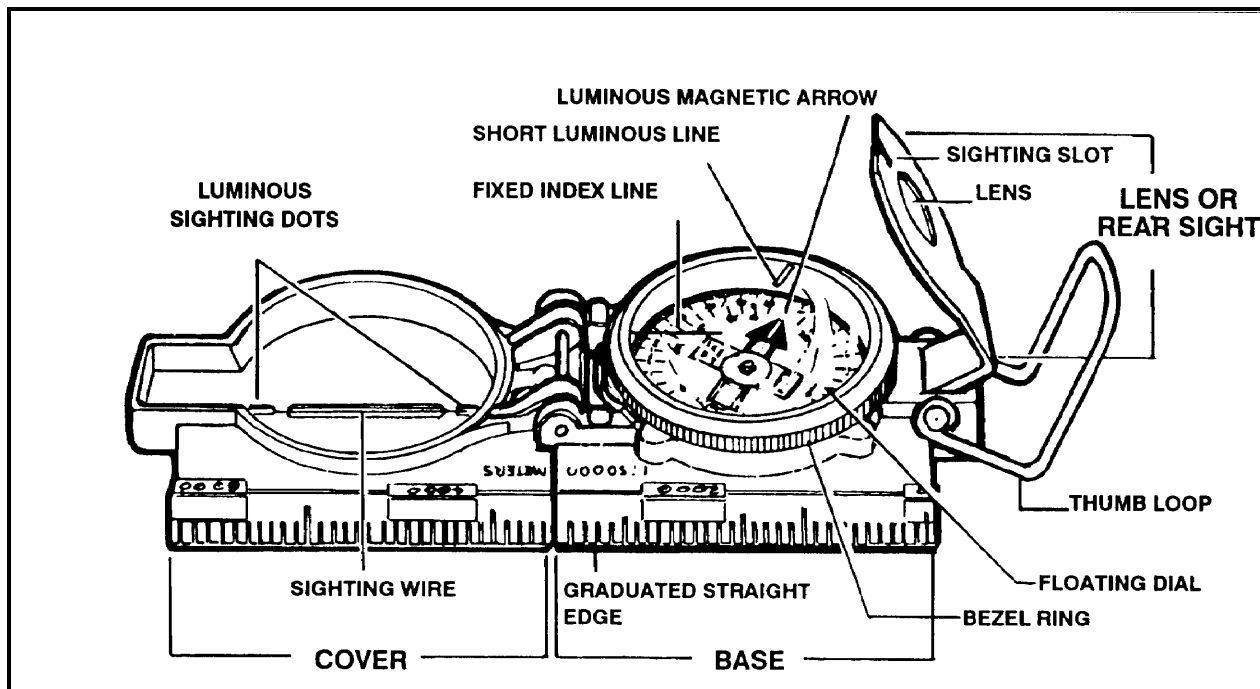


Figure 9-1. Lensatic compass.

distances are suggested to ensure proper functioning of a compass:

High-tension power lines	55 meters.
Field gun, truck, or tank	18 meters.
Telegraph or telephone wires and barbed wire	10 me t e rs.
Machine gun	2 meters.
Steel helmet or rifle	1/2 meter.

c. **Accuracy.** A compass in good working condition is very accurate. However, a compass has to be checked periodically on a known line of direction, such as a surveyed azimuth using a declination station. Compasses with more than 3° + variation should not be used.

d. **Protection.** If traveling with the compass unfolded, make sure the rear sight is fully folded down onto the bezel ring. This will lock the floating dial and prevent vibration, as well as protect the crystal and rear sight from damage.

9-4. USING A COMPASS

Magnetic azimuths are determined with the use of magnetic instruments, such as lensatic and M-2 compasses. The techniques employed when using the lensatic compass are as follows:

a. **Using the Centerhold Technique.** First, open the compass to its fullest so that the cover forms a straightedge with the base. Move the lens (rear sight) to the rearmost position, allowing the dial to float freely. Next, place your thumb through the thumb loop, form a steady base with your third and fourth fingers, and extend your index finger along the side of the compass. Place the thumb of the other hand between the lens (rear sight) and the bezel ring; extend the index finger along the remaining side of the compass, and the remaining fingers around the fingers of the other hand. Pull your elbows firmly into your sides; this will place the compass between your chin and your belt. To measure an azimuth, simply turn your entire body toward the object, pointing the compass cover directly at the object. Once you are pointing at the object, look down and read the azimuth from beneath the fixed black index line (Figure 9-2). This preferred method offers the following advantages over the sighting technique:

- (1) It is faster and easier to use.
- (2) It can be used under all conditions of visibility.
- (3) It can be used when navigating over any type of terrain.
- (4) It can be used without putting down the rifle; however, the rifle must be slung well back over either shoulder.
- (5) It can be used without removing eyeglasses.

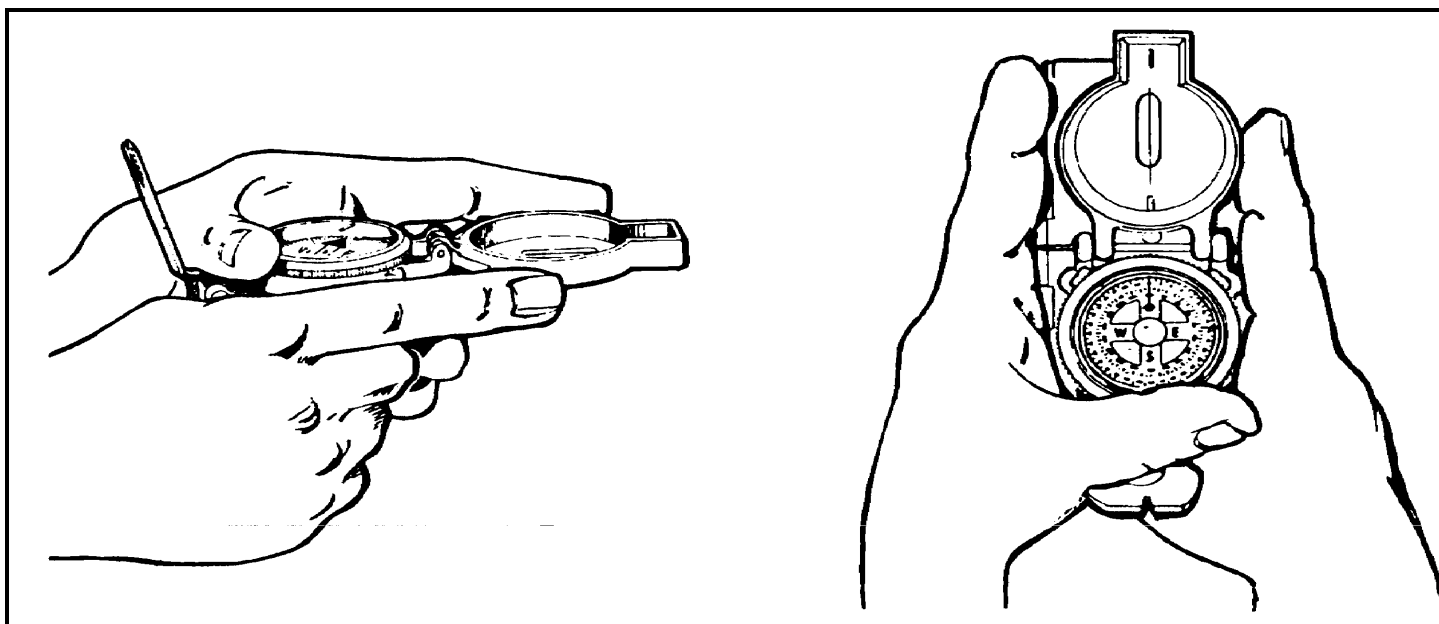


Figure 9-2. Centerhold technique.

b. **Using the Compass-to-Cheek Technique.** Fold the cover of the compass containing the sighting wire to a vertical position; then fold the rear sight slightly forward. Look through the rear-sight slot and align the front-sight hairline with the desired object in the

distance. Then glance down at the dial through the eye lens to read the azimuth (Figure 9-3).

NOTE: The compass-to-cheek technique is used almost exclusively for sighting, and it is the best technique for this purpose.



Figure 9-3. Compass-to-cheek technique.

c. Presetting a Compass and Following an Azimuth. Although different models of the lensatic compass vary somewhat in the details of their use, the principles are the same.

(1) During daylight hours or with a light source:

(a) Hold the compass level in the palm of the hand.

(b) Rotate it until the desired azimuth falls under the fixed black index line (for example, 320°), maintaining the azimuth as prescribed (Figure 9-4).

(c) Turn the bezel ring until the luminous line is aligned with the north-seeking arrow. Once the alignment is obtained, the compass is preset.

(d) To follow an azimuth, assume the centerhold technique and turn your body until the north-seeking arrow is aligned with the luminous line. Then proceed forward in the direction of the front cover's sighting wire, which is aligned with the fixed black index line that contains the desired azimuth.

(2) During limited visibility, an azimuth may be set on the compass by the click method. Remember that the bezel ring contains 3° intervals (clicks).

(a) Rotate the bezel ring until the luminous line is over the fixed black index line.

(b) Find the desired azimuth and divide it by three. The result is the number of clicks that you have to rotate the bezel ring.

(c) Count the desired number of clicks. If the desired azimuth is smaller than 180°, the number of clicks on the bezel ring should be counted in a counterclockwise direction. For example, the desired azimuth is 51°. Desired azimuth is $51^\circ \div 3 = 17$ clicks counterclockwise. If the desired azimuth is larger than 180°, subtract the number of degrees from 360° and divide by 3 to obtain the number of clicks. Count them in a clockwise direction. For example, the desired azimuth is 330°; $360^\circ - 330^\circ = 30^\circ \div 3 = 10$ clicks clockwise.

(d) With the compass preset as described above, assume a centerhold technique and rotate your body until the north-seeking arrow is aligned with the luminous line on the bezel. Then proceed forward in the direction of the front cover's luminous dots, which are aligned with the fixed black index line containing the azimuth.

(e) When the compass is to be used in darkness, an initial azimuth should be set while light is still available, if possible. With the initial azimuth as a

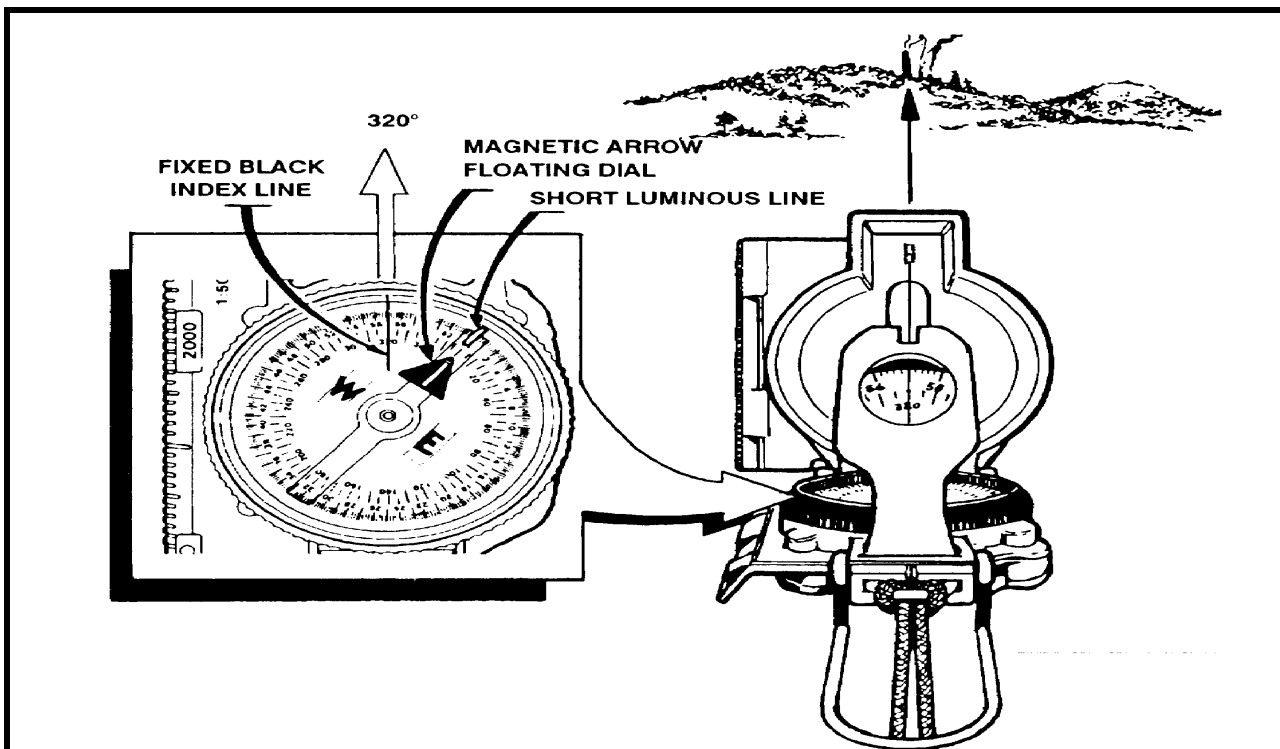


Figure 9-4. Compass preset at 320 degrees.

base, any other azimuth that is a multiple of three can be established through the use of the clicking feature of the bezel ring.

NOTE: Sometimes the desired azimuth is not exactly divisible by three, causing an option of rounding up or rounding down. If the azimuth is rounded up, this causes an increase in the value of the azimuth, and the object is to be found on the left. If the azimuth is rounded down, this causes a decrease in the value of the azimuth, and the object is to be found on the right.

d. **Bypassing an Obstacle.** To bypass enemy positions or obstacles and still stay oriented, detour around the obstacle by moving at right angles for specified distances.

(1) For example, while moving on an azimuth of 90° , change your azimuth to 180° and travel for 100 meters; change your azimuth to 90° and travel for 150 meters; change your azimuth to 360° and travel for 100 meters; then change your azimuth to 90° and you are back on your original azimuth line (Figure 9-5).

(2) Bypassing an unexpected obstacle at night is a fairly simple matter. To make a 90° turn to the right, hold the compass in the centerhold technique; turn until the center of the luminous letter E is under the luminous line (do not move the bezel ring). To make a 90° turn to the left, turn until the center of the luminous letter W is under the luminous line. This does not require changing the compass setting (bezel ring), and it ensures accurate 90° turns.

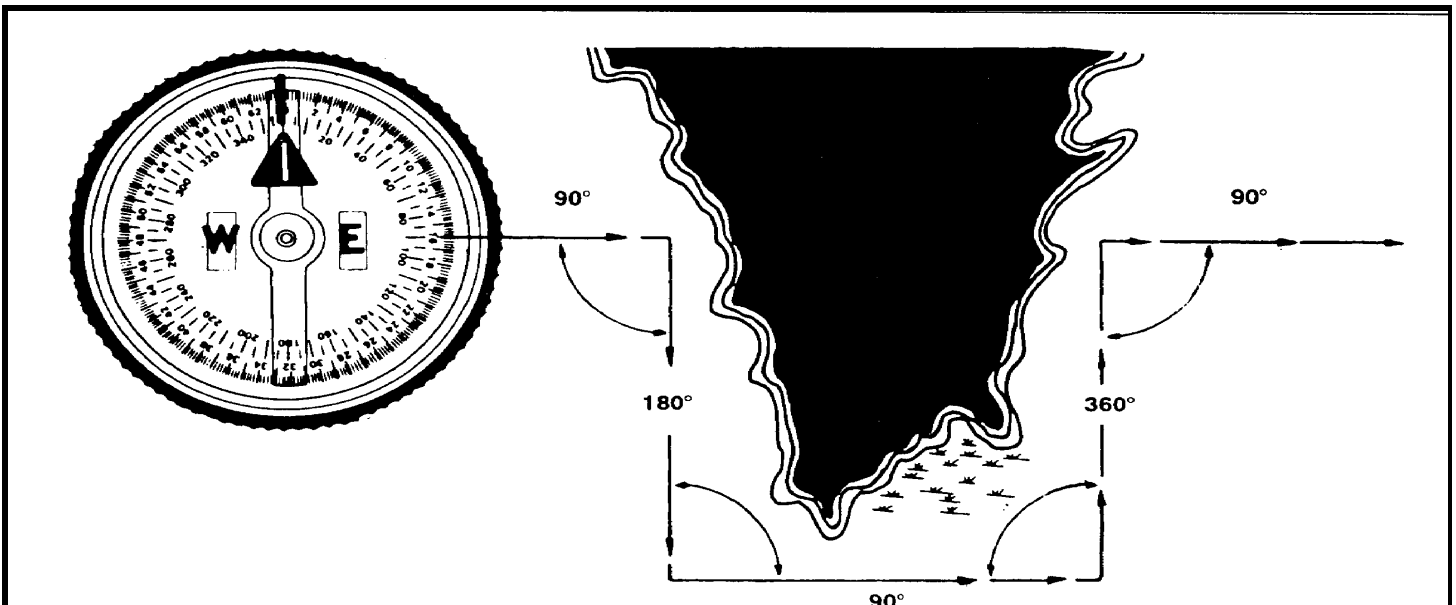


Figure 9-5. Bypassing an obstacle.

e. **Offset.** A deliberate offset is a planned magnetic deviation to the right or left of an azimuth to an objective. Use it when the objective is located along or in the vicinity of a linear feature such as a road or stream. Because of errors in the compass or in map reading, the linear feature may be reached without knowing whether the objective lies to the right or left. A deliberate offset by a known number of degrees in a known direction compensates for possible errors and ensures that upon reaching the linear feature, the user knows whether to go right or left to reach the objective. Ten degrees is an adequate offset for most tactical uses. Each degree offset will move the course about 18 meters to the right or left for each 1,000 meters traveled. For example, in Figure 9-6, the number of degrees offset is 10. If the distance traveled to "x" in 1,000 meters, then "x" is located about 180 meters to the right of the objective.

9-5. FIELD-EXPEDIENT METHODS

When a compass is not available, different techniques should be used to determine the four cardinal directions.

a. Shadow-Tip Method.

(1) This simple and accurate method of finding direction by the sun consists of four basic steps (Figure 9-7).

Step 1. Place a stick or branch into the ground at a level spot where a distinctive shadow will be cast. Mark the shadow tip with a stone, twig, or other means. This first shadow mark is always the west direction.

Step 2. Wait 10 to 15 minutes until the shadow tip moves a few inches. Mark the new position of the shadow tip in the same way as the first.

Step 3. Draw a straight line through the two marks to obtain an approximate east-west line.

Step 4. Standing with the first mark (west) to your left, the other directions are simple; north is to the front, east is to the right, and south is behind you.

(2) A line drawn perpendicular to the east-west line at any point is the approximate north-south line. If you are uncertain which direction is east and which is west, observe this simple rule—the first shadow-tip mark is always in the west direction, everywhere on earth.

(3) The shadow-tip method can also be used as a shadow clock to find the approximate time of day (Figure 9-7).

(a) To find the time of day, move the stick to the intersection of the east-west line and the north-south line, and set it vertically in the ground. The west part of the east-west line indicates 0600 hours, and the east part is 1800 hours, anywhere on earth, because the basic rule always applies.

(b) The north-south line now becomes the noon line. The shadow of the stick is an hour hand in the shadow clock, and with it you can estimate the time using the noon line and the 6 o'clock line as your guides. Depending on your location and the season, the shadow may move either clockwise or counter-clockwise, but this does not alter your manner of reading the shadow clock.

(c) The shadow clock is not a timepiece in the ordinary sense. It makes every day 12 unequal hours long, and always reads 0600 hours at sunrise and 1800 hours at sunset. The shadow clock time is closest to conventional clock time at midday, but the spacing of the

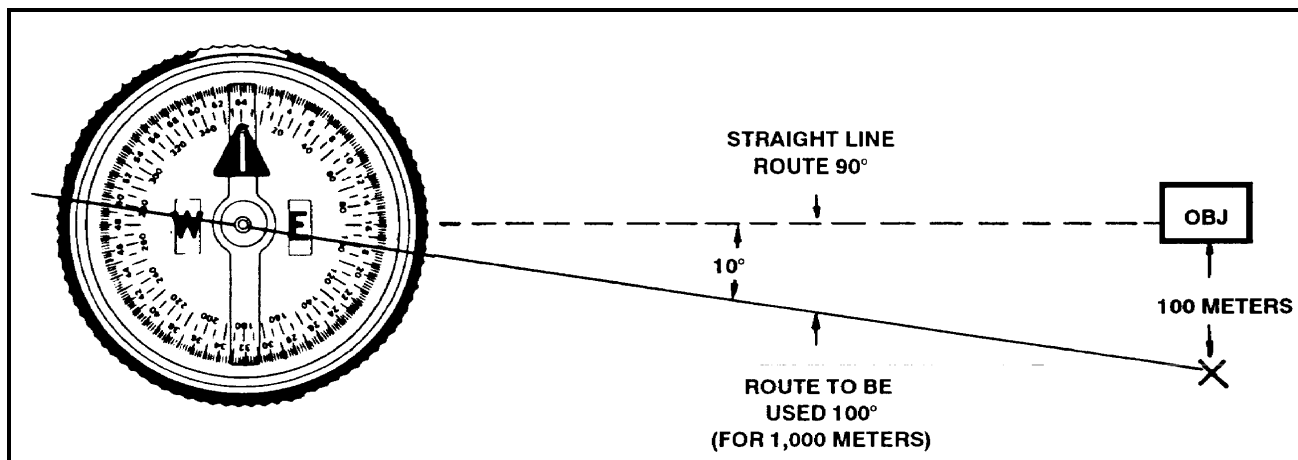


Figure 9-6. Deliberate offset to the objective.

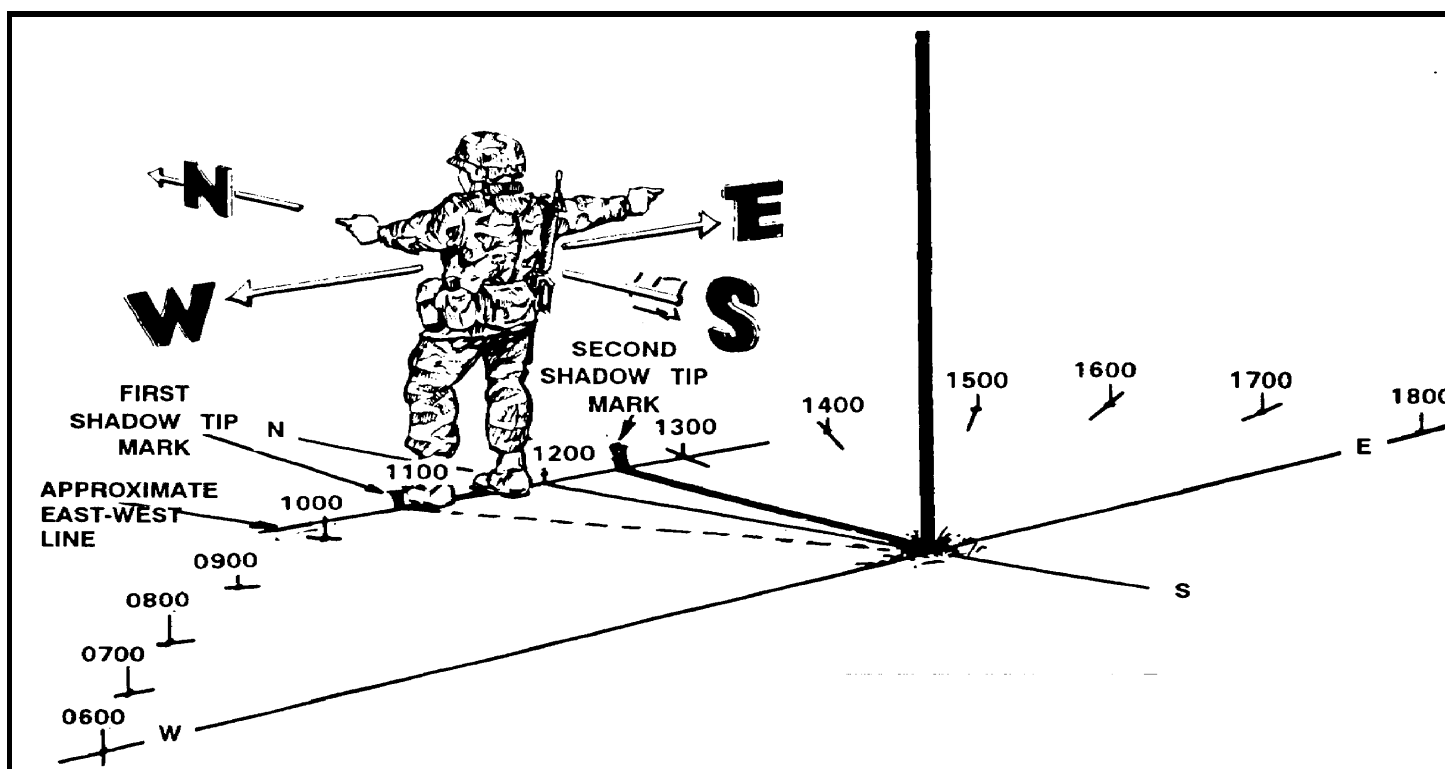


Figure 9-7. Determining directions and time by shadow.

other hours compared to conventional time varies somewhat with the locality and the date. However, it does provide a satisfactory means of telling time in the absence of properly set watches.

(d) The shadow-tip system is not intended for use in polar regions, which the Department of Defense defines as, being above 60° latitude in either hemisphere. Distressed persons in these areas are advised to stay in one place so that search/rescue teams may easily find them. The presence and location of all aircraft and ground parties in polar regions are reported to and checked regularly by governmental or other agencies, and any need for help becomes quickly known.

b. Watch Method.

(1) A watch can be used to determine the approximate true north and true south. In the north temperate zone only, the hour hand is pointed toward the sun. A south line can be found midway between the hour hand and 1200 hours, standard time. If on daylight saving time, the north-south line is found between the hour hand and 1300 hours. If there is any doubt as to which end of the line is north, remember that the sun is in the east before noon and in the west after noon.

(2) The watch may also be used to determine direction in the south temperate zone; however, the method is different. The 1200-hour dial is pointed toward the sun, and halfway

between 1200 hours and the hour hand will be a north line. If on daylight saving time, the north line lies midway between the hour hand and 1300 hours (Figure 9-8).

(3) The watch method can be in error, especially in the lower latitudes, and may cause circling. To avoid this, make a shadow clock; and set your watch to the time indicated. After traveling for an hour, take another shadow-clock reading. Reset your watch if necessary.

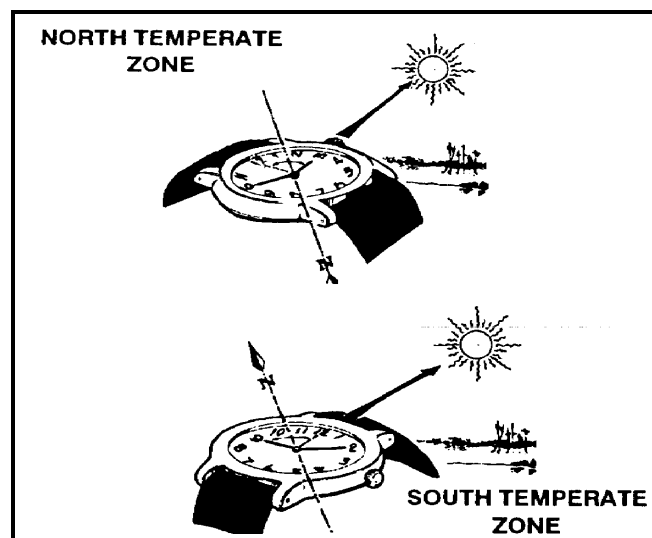


Figure 9-8. Determining direction by using a watch.

c. Star Method.

(1) Less than 60 of approximately 5,000 stars visible to the eye are used by navigators. The stars seen as we look up at the sky at night are not evenly scattered across the whole sky. Instead they are in groups called constellations.

(2) The constellations that we see depend partly on where we are located on the earth, the time of the year, and the time of the night. The night changes with the seasons because of the journey of the earth around the sun, and it also changes from hour to hour because the turning of the earth makes some constellations seem to travel in a circle. But there is one star that is in almost exactly the same place in the sky all night long every night. It is the North Star, also known as the Polar Star or Polaris.

(3) The North Star is less than 1° off true north and does not move from its place because the axis of the earth is pointed toward it. The North Star is in the group of stars called the Little Dipper. It is the last star in the handle of the dipper. Two stars in the Big Dipper are a help in finding the North Star. They are called the Pointers, and an imaginary line drawn through them five times their distance points to the North Star. There are many stars brighter than the North Star, but none is more important because of its location. However, the North Star can only be seen in the northern hemisphere so it cannot serve as a guide south of the equator. The farther one goes north, the higher the North Star is in the sky, and above latitude 70° , it is too high in the sky to be useful (Figure 9-9).

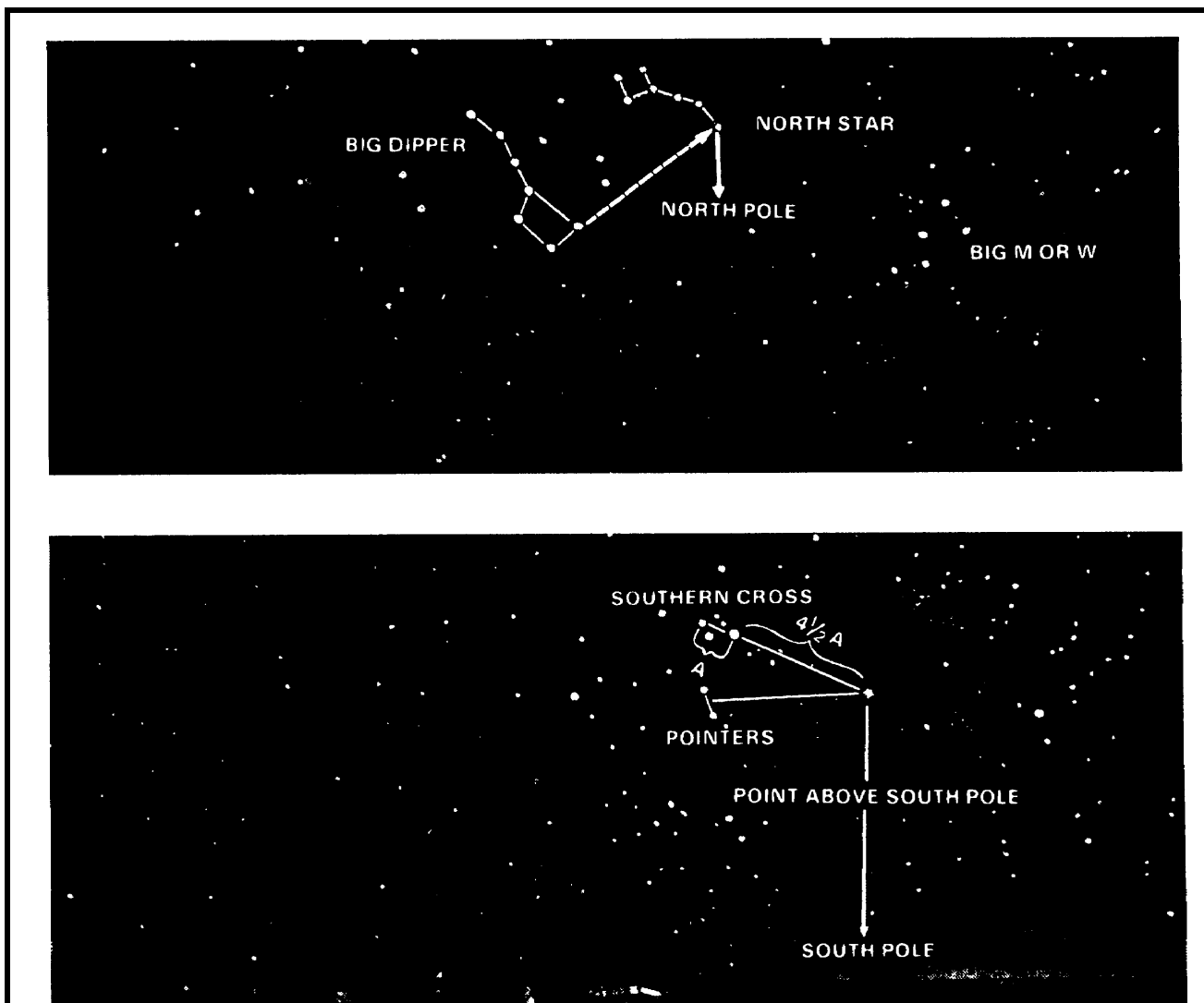
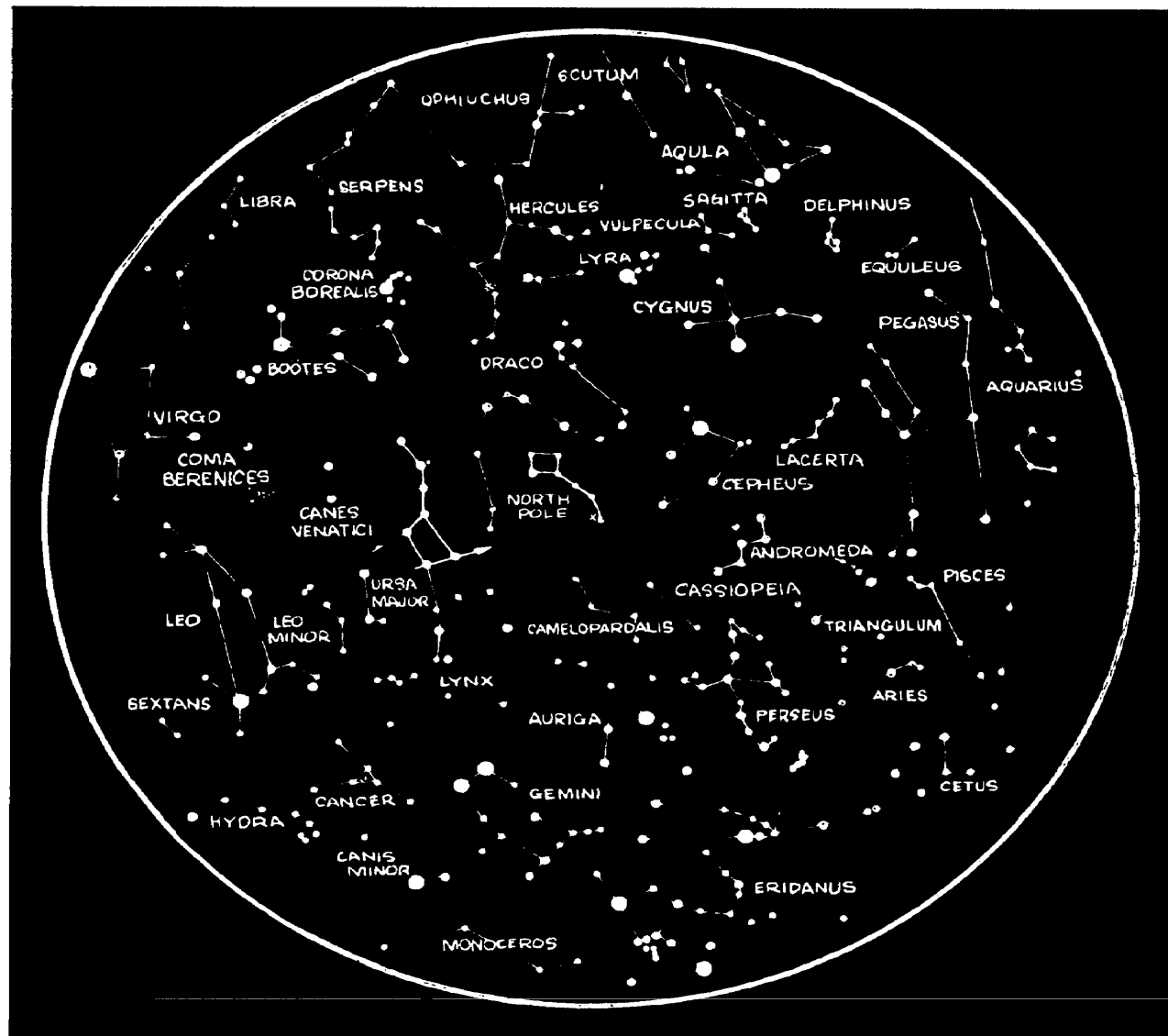


Figure 9-9. Determining direction by the North Star and the Southern Cross.

(4) Depending on the star selected for navigation, azimuth checks are necessary. A star near the north horizon serves for about a half hour. When moving south, azimuth checks should be made every 15 minutes. When traveling east or west, the difficulty of staying on azimuth is caused more by the likelihood of the star climbing too high in the sky or losing itself behind the western horizon than it is by the star changing direction

angle. When this happens, it is necessary to change to another guide star. The Southern Cross is the main constellation used as a guide south of the equator and the above general directions for using north and south stars are reversed. When navigating using the stars as guides, the user must know the different constellation shapes and their locations throughout the world (Figures 9-10 and 9-11).

Figure 9-10. Constellations, Northern Hemisphere.



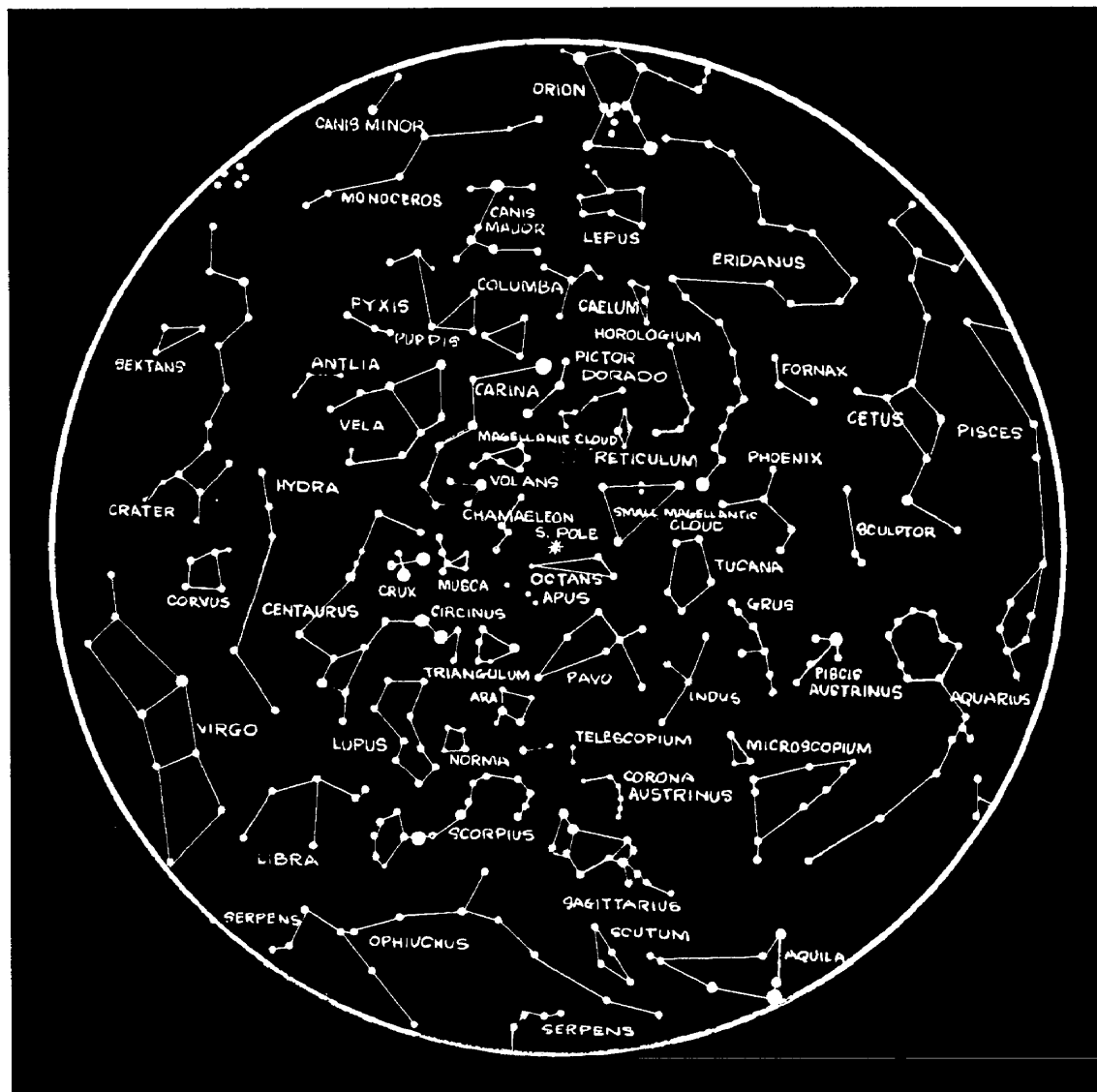


Figure 9-11. Constellations, Southern Hemisphere.

9-6. GLOBAL POSITIONING SYSTEM

The GPS is a space-based, global, all-weather, continuously available, radio positioning navigation system. It is highly accurate in determining position location derived from signal triangulation from a satellite constellation system. It is capable of determining latitude, longitude, and altitude of the individual user. It is being fielded in hand-held, manpack, vehicular, aircraft, and watercraft configurations. The GPS receives and processes data from satellites on either a

simultaneous or sequential basis. It measures the velocity and range with respect to each satellite; processes the data in terms of an earth centered, earth-fixed coordinate system; and displays the information to the user in geographic or military grid coordinates.

a. The GPS can provide precise steering information, as well as position location. The receiver can accept many checkpoints entered in any coordinate system by

the user and convert them to the desired coordinate system. The user then calls up the desired checkpoint and the receiver will display direction and distance to the checkpoint. The GPS does not have inherent drift, an improvement over the Inertial Navigation System, and the receiver will automatically update its position. The receiver can also compute time to the next checkpoint.

c. Specific uses for the GPS are position location; navigation; weapon location; target and sensor location; coordination of firepower, scout and screening opera-

tions; combat resupply; location of obstacles, barriers, and gaps; and communication support. The GPS also has the potential to allow units to train their soldiers and provide the following:

- Performance feedback.
- Knowledge of routes taken by the soldier.
- Knowledge of errors committed by the soldier.
- Comparison of planned versus executed routes.
- Safety and control of lost and injured soldiers. (See

Appendix J for more information of the GPS.)