CHAPTER 5

LEVELING AND GRADING

This chapter describes the common types of leveling instruments. It also describes their principles, uses, procedures of establishing elevations, and techniques of laying outbuilding lines. As a Builder, you will find the information especially useful in performing such duties as setting up a level, reading a leveling rod, interpreting and setting grade stakes, and setting batterboards. Also included in this chapter are practices and measures that help prevent slides and cave-ins at excavation sites, and the procedures for computing volume of land mass.

LEVELS

LEARNING OBJECTIVE: Upon completing this section, you should be able to describe the types of leveling instruments and their uses.

The engineer's level, often referred to as the "dumpy level," is the instrument most commonly used to attain the level line of sight required for differential leveling (defined later). The dumpy level and the self-leveling level can be mounted for use on a tripod, usually with adjustable legs (figure 5-1).

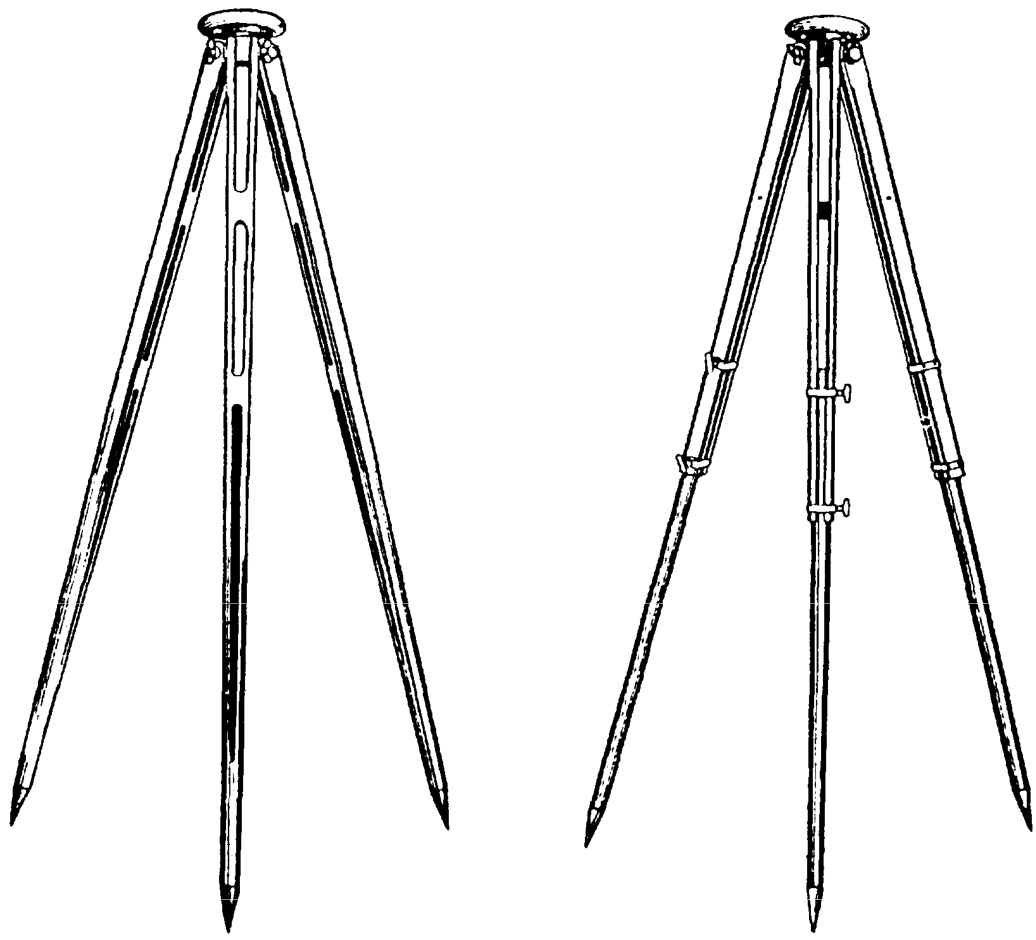

Figure 5-1.—Tripods.

Mounting is done by engaging threads at the base of the instrument (called the footplate) with the threaded head on the tripod. These levels are the ones most frequently used in ordinary leveling projects. For rough leveling, the hand level is used.

DUMPY LEVEL

Figure 5-2 shows a dumpy level and its nomenclature. Notice that the telescope is rigidly fixed to the supporting frame.

Inside the telescope there is a ring, or diaphragm, known as the reticle, which supports the cross hairs. The cross hairs are brought into exact focus by manipulating the knurled eyepiece focusing ring near the eyepiece, or the eyepiece itself on some models. If the cross hairs get out of horizontal adjustment, they can be made horizontal again by slackening the reticle adjusting screws and turning the screws in the appropriate direction. This adjustment should be performed only by trained personnel. The object to which you are sighting, regardless of shape, is called a target. The target is brought into clear focus by manipulating the focusing knob shown on top of the telescope. The telescope can be rotated only horizontally, but, before it can be rotated, the azimuth clamp must be released. After training the telescope as nearly on the target as you can, tighten the azimuth clamp. You then bring the vertical cross hair into exact alignment on the target by rotating the azimuth tangent screw.

The level vial, leveling head, leveling screws, and footplate are all used to adjust the instrument to a perfectly level line of sight once it is mounted on the tripod.

SELF-LEVELING LEVEL

You can save time using the self-leveling, or so-called “automatic,” level in leveling operations. The self-leveling level (figure 5-3) has completely eliminated the use of the tubular spirit level, which required excessive time because it had to be reset quite often during operation.

The self-leveling level is equipped with a small bull‘s-eye level and three leveling screws. The leveling screws, which sit on a triangular footplate,

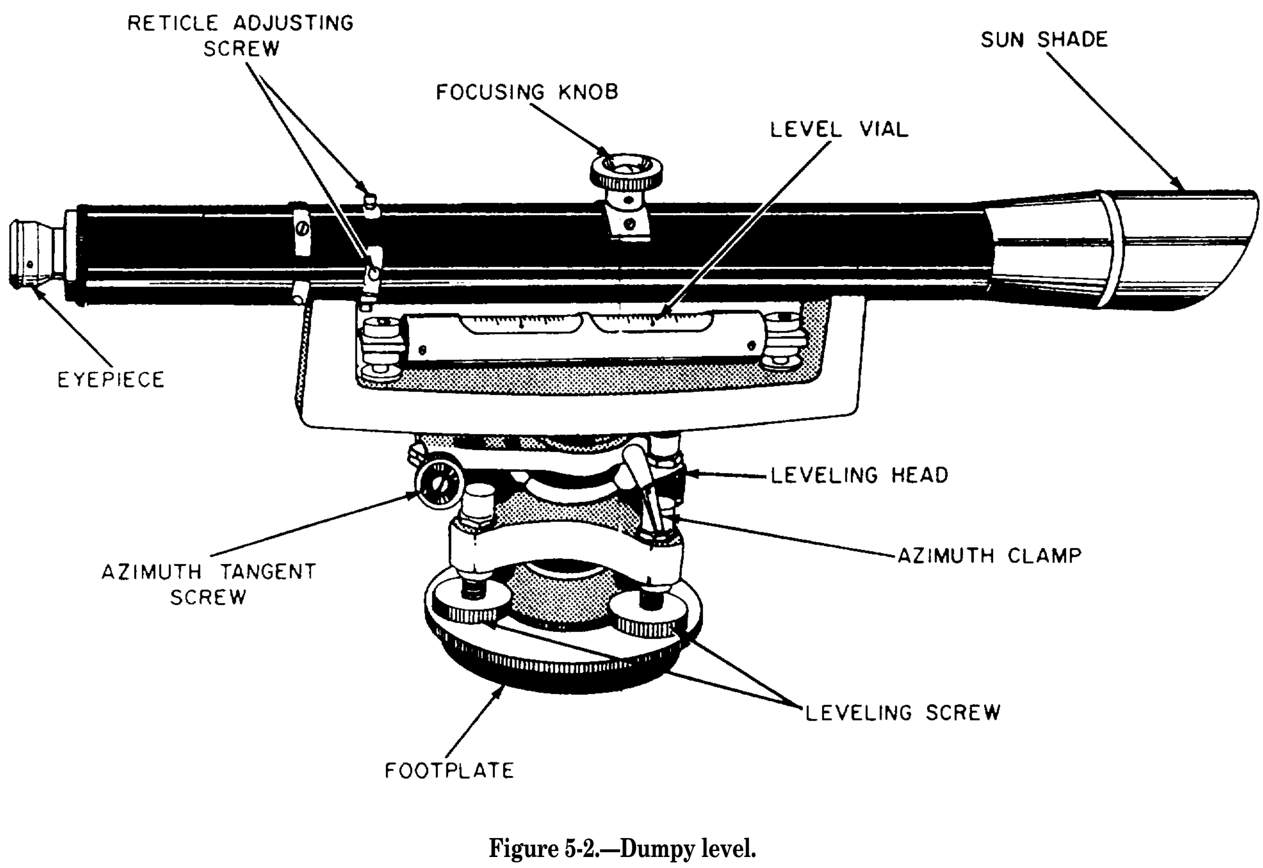

Figure 5-2.—Dumpy level.

are used to center, as much as possible, the bubble of the bull's-eye level. The line of sight automatically becomes horizontal and remains horizontal as long as the bubble remains approximately centered.

HAND LEVEL

The hand level, like all surveying levels, is an instrument that combines a level vial and a sighting device. Figure 5-4 shows the Locke level, a type of hand level. A horizontal line, called an index line, is provided in the sight tube as a reference line. The level vial is mounted atop a slot in the sighting tube in which a reflector is set at a 45° angle. This permits the observer, who is sighting through the tube, to see the object, the position of the level bubble in the vial, and the index line at the same time.

To get the correct sighting through the tube, you should stand straight, using the height of your eye (if known) above the ground to find the target. When your eye height is not known, you can find it by sighting the rod at eye height in front of your body. Since the distances over which you sight a hand level are rather short, no magnification is provided in the tube.

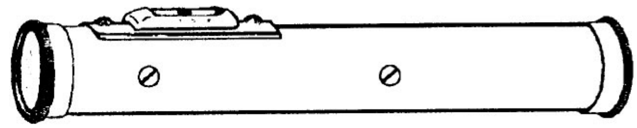

Figure 5-4.—Locke level.

SETTING UP A LEVEL

After you select the proper location for the level, your first step is to set up the tripod. This is done by spreading two of the legs a convenient distance apart and then bringing the third leg to a position that will bring the protector cap (which covers the tripod head threads) about level when the tripod stands on all three legs. Then, unscrew the protector cap, which exposes the threaded head, and place it in the carrying case where it will not get lost or dirty. The tripod protective cap should be in place when the tripod is not being used.

Lift the instrument out of the carrying case by the footplate-not by the telescope. Set it squarely and gently on the tripod head threads and engage the head nut threads under the footplate by rotating the footplate clockwise. If the threads will not engage

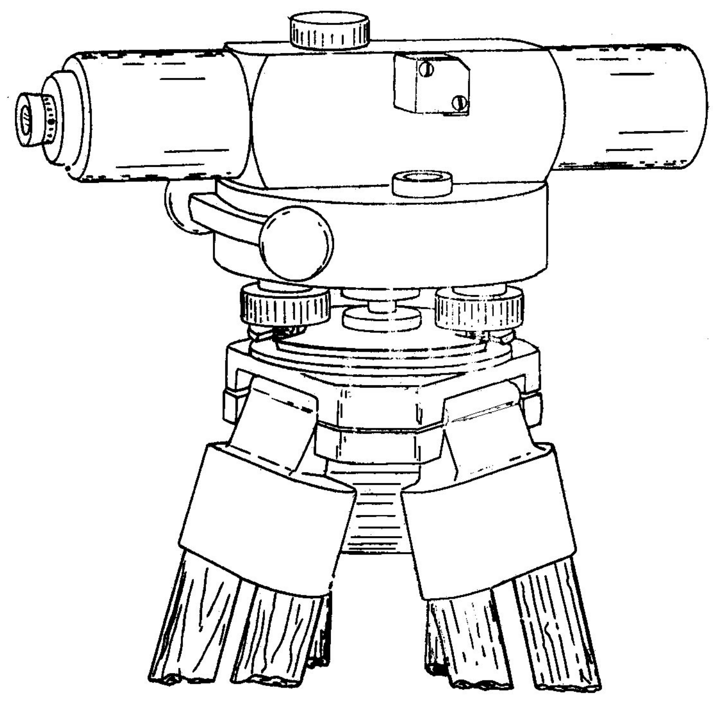

Figure 5-3.—Self-leveling level.

smoothly, they may be cross-threaded or dirty. Do not force them if you encounter resistance; instead, back off, and, after checking to see that they are clean, square up the instrument, and then try again gently. Screw the head nut up firmly, but not too tightly. Screwing it too tightly causes eventual wearing of the threads and makes unthreading difficult. After you have attached the instrument, thrust the leg tips into the ground far enough to ensure that each leg has stable support, taking care to maintain the footplate as near level as possible. With the instrument mounted and the legs securely positioned in the soil, the thumbscrews at the top of each leg should be firmly tightened to prevent any possible movement.

Quite frequently, the Builder must set up the instrument on a hard, smooth surface, such as a concrete pavement. Therefore, steps must be taken to prevent the legs from spreading. Figure 5-5 shows two good ways of doing this. In view A, the tips of the legs are inserted in joints in the pavement. In view B, the tips are held by a wooden floor triangle.

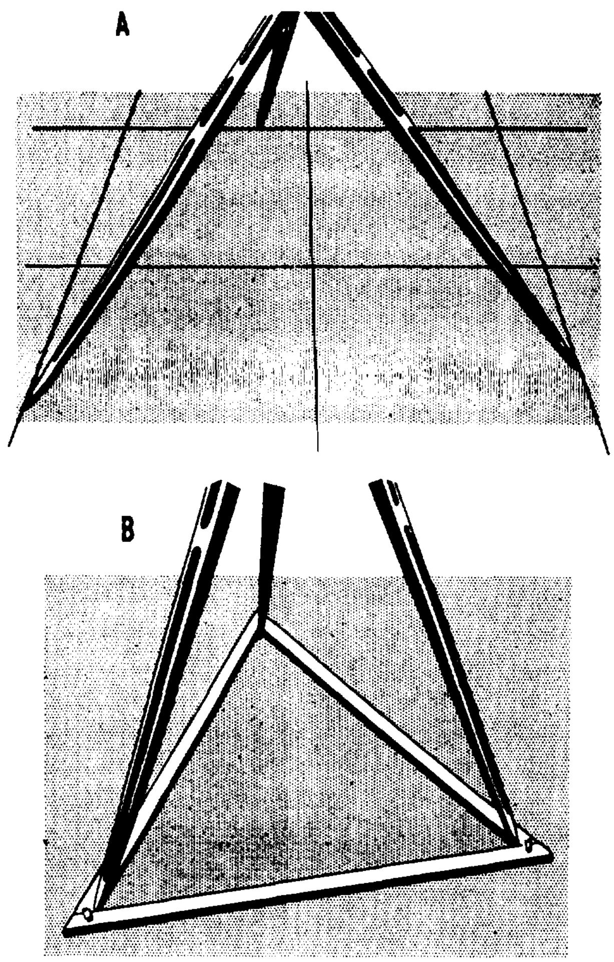

Figure 5-5.—Methods of preventing tripod legs from spreading.

LEVELING A LEVEL

To function accurately, the level must provide a line of sight that is perfectly horizontal in any direction the telescope is trained. To ensure this, you must level the instrument as discussed in the next paragraphs.

When the tripod and instrument are first set up, the footplate should be made as nearly level as possible. Next, train the telescope over a pair of diagonally opposite leveling screws, and clamp it in that position. Then, manipulate the leveling thumbscrews, as shown in figure 5-6, to bring the bubble in the level vial exactly into the marked center position.

The thumbscrews are manipulated by simultaneously turning them in opposite directions, which shortens one spider leg (threaded member running through the thumbscrew) while it lengthens the other. It is helpful to remember that the level vial bubble will move in the same direction that your left thumb moves while you rotate the thumbscrews. In other words, when your left thumb pushes the thumbscrew clockwise, the bubble will move towards your left hand; when you turn the left thumbscrew counterclockwise, the bubble moves toward your right hand.

After leveling the telescope over one pair of screws, train it over the other pair and repeat the process. As a check, set the telescope in all four possible positions and be sure that the bubble centers exactly in each.

Various techniques for using the level will develop with experience; however, in this section we will only discuss the techniques that we believe are essential to the Builder rating.

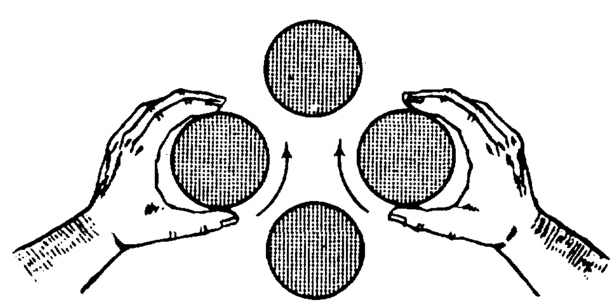

Figure 5-6.—Manipulating leveling thumbscrews.

CARE OF LEVELS

An engineer's level is a precision instrument containing many delicate and fragile parts. It must therefore be handled gently and with the greatest care at all times; it must never be subjected to shock or jar. Movable parts (if not locked or clamped in place) should work easily and smoothly. If a movable part resists normal pressure, there is something wrong. If you force the part to move, you will probably damage the instrument. You will also cause wear or damage if you excessively tighten clamps and screws.

The only proper place to stow the instrument when it is detached from the tripod is in its own carrying box or case. The carrying case is designed to reduce the effect of jarring to a minimum. It is strongly made and well padded to protect the instrument from damage. Before stowing, the azimuth clamp and leveling screws should be slightly tightened to prevent movement of parts inside the box. When it is being transported in a vehicle, the case containing the instrument should be placed as nearly as possible midway between the front and rear wheels. This is the point where jarring of the wheels has the least effect on the chassis.

You should never lift the instrument out of the case by grasping the telescope. Wrenching the telescope in this manner will damage a number of delicate parts. Instead, lift it out by reaching down and grasping the footplate or the level bar.

When the instrument is attached to the tripod and carried from one point to another, the azimuth clamp and level screws should be set up tight enough to prevent part motion during the transport but loose enough to allow a "give" in case of an accidental bump against some object. When you are carrying the instrument over terrain that is free of possible contacts (across an open field, for example), you may carry it over your shoulder like a rifle. When there are obstacles around, you should carry it as shown in figure 5-7. Carried in this manner, the instrument is always visible to you, and this makes it possible for you to avoid striking it against obstacles.

Figure 5-7.—Safest carrying position for instrument when obstacles may be encountered.

LEVELING RODS

LEARNING *OBJECTIVE: Upon completing this section, you should be able to interpret the readings from a leveling rod.*

A leveling rod, in essence, is a tape supported vertically that is used to measure vertical distance (difference in elevation) between a line of sight and a required point above or below it. Although there are several types of rods, the most popular and frequently used is the Philadelphia rod. Figure 5-8 shows the face and back of this rod.

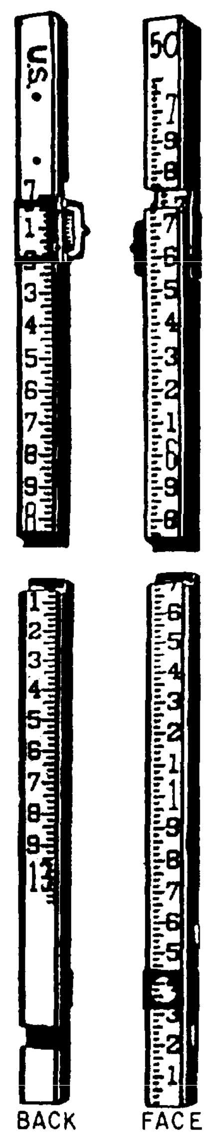

Figure 5-8.—Back and face of Philadelphia leveling rod.

The Philadelphia rod consists of two sliding sections, which can be fully extended to a total length of 13.10 feet. When the sections are entire] y closed, the total length is 7.10 feet. For direct readings (that is, for readings on the face of the rod) of up to 7.10 and 13.10 feet, the rod is used extended and read on the back by the rodman. If you are in the field and don't have a Philadelphia rod, you can use a 1-by-4 with a mark or a 6-foot wooden ruler attached to a 2-by-4.

In direct readings, the person at the instrument reads the graduation on the rod intercepted by the cross hair through the telescope. In target readings, the rodman reads the graduation on the face of the rod intercepted by a target. In figure 5-8, the target does not appear; however, it is shown in figure 5-9. As you can see, it is a sliding, circular device that can be moved up or down the rod and clamped in position. It

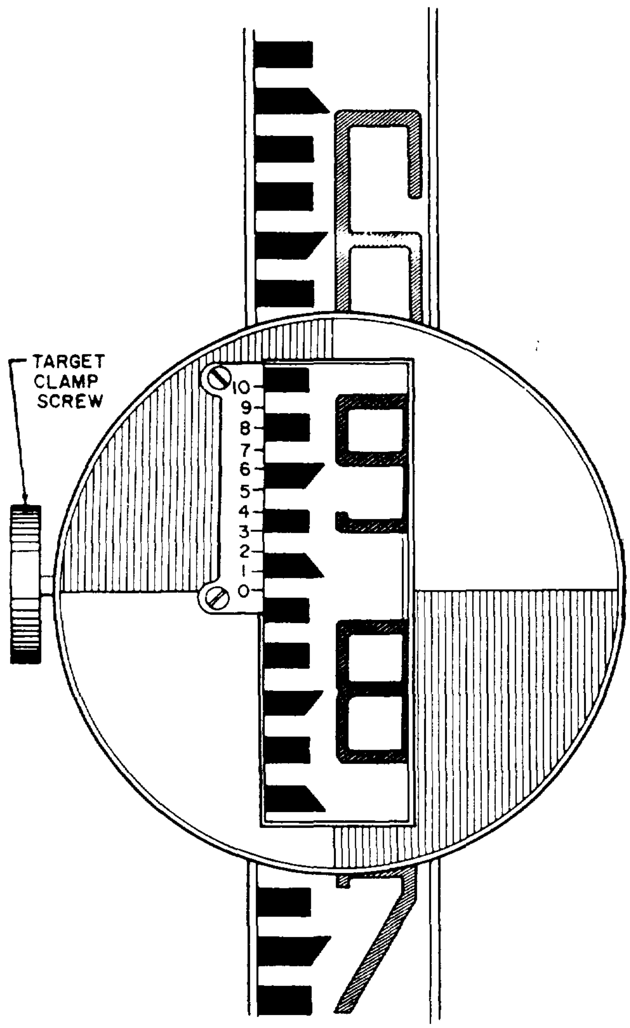

Figure 5-9.—Philadelphia rod set for target reading of less than 7,000 feet.

is placed by the rodman on signals given by the instrumentman.

The rod shown in the figures is graduated in feet and hundredths of a foot. Each even foot is marked with a large red numeral, and, between each pair of adjacent red numerals, the intermediate tenths of a foot are marked with smaller black numerals. Each intermediate hundredth of a foot between each pair of adjacent tenths is indicated by the top or bottom of one of the short, black dash graduations.

DIRECT READINGS

As the levelman, you can make direct readings on a self-reading rod held plumb on the point by the rodman. If you are working to tenths of a foot, it is relatively simple to read the footmark below the cross hair and the tenth mark that is closest to the cross hair. If greater precision is required, and you must work to hundredths, the reading is more complicated (see figure 5-10).

For example, suppose you are making a direct reading that should come out to 5.67 feet. If you are using a Philadelphia rod, the interval between the top and the bottom of each black graduation and the interval between the black graduations (figure 5-11) each represent 0.01 foot. For a reading of 5.76 feet, there are three black graduations between the 5.70-foot mark and the 5.76-foot mark. Since there are three graduations, a beginner may have a tendency to misread 5.76 feet as 5.73 feet.

As you can see, neither the 5-foot mark nor the 6-foot mark is shown in figure 5-11. Sighting through the telescope, you might not be able to see the foot marks to which you must refer for the reading. When you cannot see the next lower foot mark through the telescope, it is a good idea to order the rodman to **raise the red.** On the Philadelphia rod, whole feet numerals are in red. Upon hearing this order, the rodman slowly raises the rod until the next lower red figure comes into view.

TARGET READINGS

For more precise vertical measurements, level rods may be equipped with a rod target that can be set and clamped by the rodman at the directions of the instrumentman. When the engineer's level rod target and the vernier scale are being used, it is possible to make readings of 0.001 (one-thousandth of a foot), which is slightly smaller than one sixty-fourth of an

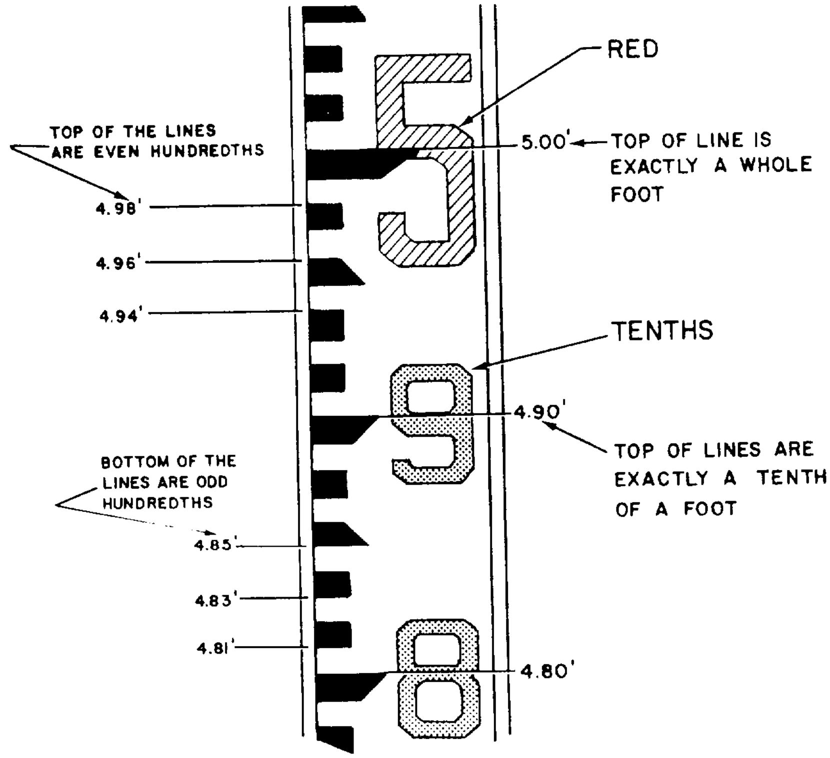

Figure 5-10.—Philadelphia rod marking.

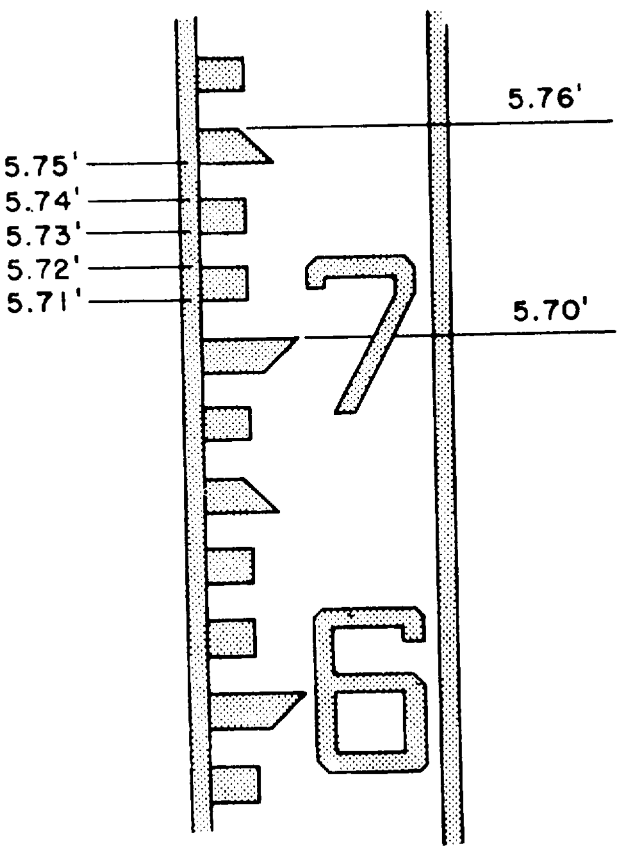

Figure 5-11.—Direct reading of 5.76 ft on Philadelphia rod.

inch. The indicated reading of the target can be read either by the rodman or the instrumentman. In figure 5-12, you can see that the 0 on the vernier scale is in exact alignment with the 4-foot mark. If the position of the 0 on the target is not in exact alignment with a line on the rod, go up the vernier scale on the target to the line that is in exact alignment with the hundredths line on the rod, and the number located will be the reading in thousandths.

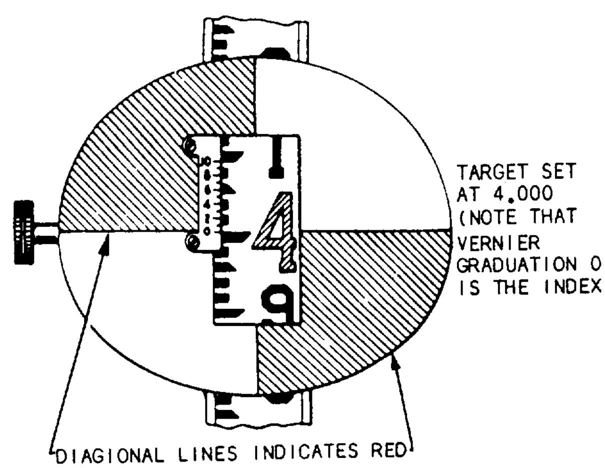

Figure 5-12.—Target.

There are three situations in which target reading, rather than direct reading, is done on the face of the rod:

- When the rod is too far from the level to be read directly through the telescope:
- When a reading to the nearest 0.001 foot, rather than to the nearest 0.01 foot, is desired (a vernier on the target or on the back of the rod makes this possible;
- When the instrumentman desires to ensure against the possibility of reading the wrong foot (large red letter) designation on the rod.

For target readings up to 7.000 feet, the rod is used fully closed, and the rodman, on signals from the instrumentman, sets the target at the point where its horizontal axis is intercepted by the cross hair, as seen through the telescope. When the target is located, it is clamped in place with the target screw clamp, as shown in figure 5-9. When a reading to only the nearest 0.01 foot is desired, the graduation indicated by the target's horizontal axis is read; in figure 5-9, this reading is 5.84 feet.

If reading to the nearest 0.001 foot is desired, the rodman reads the vernier (small scale running from 0 to 10) on the target. The 0 on the vernier indicates that the reading lies between 5.840 feet and 5.850 feet. To determine how many thousandths of a foot over 5.840 feet, you examine the graduations on the vernier to determine which one is most exactly in line with a graduation (top or bottom of a black dash) on the rod. In figure 5-9, this graduation on the vernier is the 3; therefore, the reading to the nearest 0.001 foot is 5.843 feet.

For target readings of more than 7.000 feet, the procedure is a little different. If you look at the left-hand view of figure 5-8 (showing the back of the rod), you will see that only the back of the upper section is graduated, and that it is graduated downward from 7.000 feet at the top to 13.09 feet at the bottom. You can also see there is a rod vernier fixed to the top of the lower section of the rod. This vernier is read against the graduations on the back of the upper section.

For a target reading of more than 7.000 feet, the rodman first clamps the target at the upper section of the rod. Then, on signals from the instrumentman, the rodman extends the rod upward to the point where the horizontal axis of the target is intercepted by the cross hair. The rodman then clamps the rod, using the rod clamp screw shown in figure 5-13, and reads the vernier on the back of the rod, also shown in that figure. In this case, the 0 on the vernier indicates a certain number of thousandths more than 7.100 feet. Remember, that in this case, you read the rod and the vernier down from the top, not up from the bottom. To determine the thousandths, determine which vernier graduation lines up most exactly with a graduation on the rod. In this case, it is the 7; therefore, the rod reading is 7.107 feet.

Rod Levels

A rod reading is accurate only if the rod is perfectly plumb (vertical) at the time of the reading. If the rod is out of plumb, the reading will be greater than the actual vertical distance between the height of

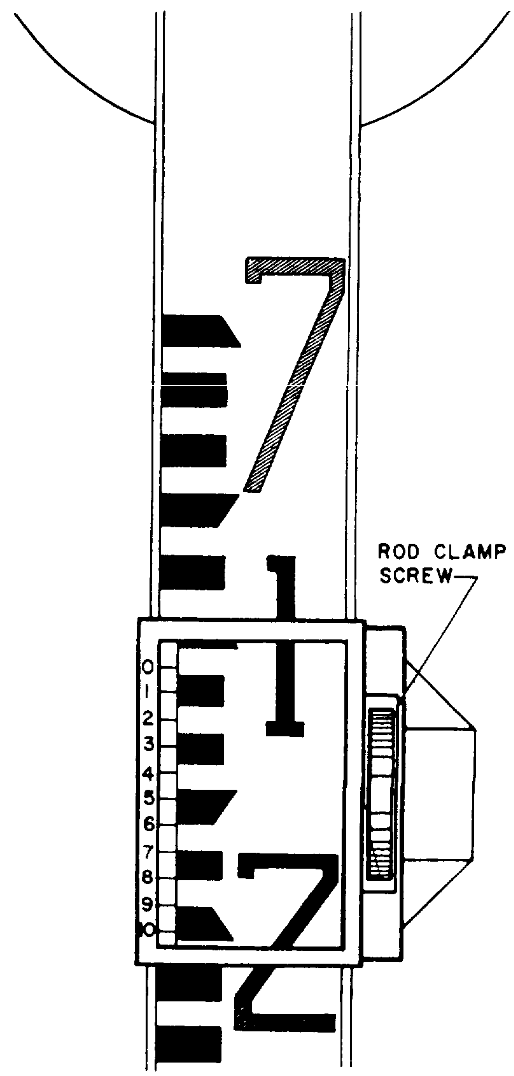

Figure 5-13.—Philadelphia rod target reading of more than 7.000 ft.

instrument (H.I.) and the base of the rod. On a windy day, the rodman may have difficulty holding the rod plumb. In this case, the levelman can have the rodman wave the rod back and forth, allowing the levelman to read the lowest reading touched on the engineer's level cross hairs.

The use of a rod level ensures a vertical rod. A bull's-eye rod level is shown in figure 5-14. When it is held as shown (on a part of the rod where readings are not being taken to avoid interference with the instrumentman's view of the scale) and the bubble is centered, the rod is plumb. A vial rod level has two spirit vials, each of which is mounted on the upper edge of one of a pair of hinged metal leaves. The vial level is used like the bull' s-eye level, except that two bubbles must be watched instead of one.

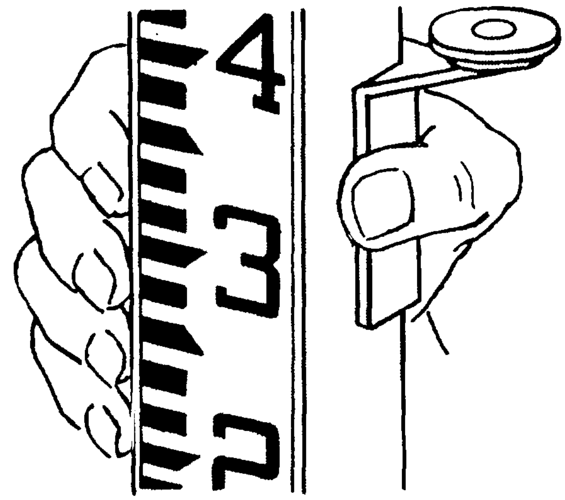

Figure 5-14.—Bull's-eye rod level.

Care of Leveling Rods

A leveling rod is a precision instrument and must be treated as such. Most rods are made of carefully selected, kiln-dried, well-seasoned hardwood. Scale graduations and numerals on some are painted directly on the wood; however, on most reds they are painted on a metal strip attached to the wood. Unless a rod is handled at all times with great care, the painted scale will soon become scratched, dented, worn, or otherwise marked and obscured. Accurate readings on a scale in this condition are difficult.

Allowing an extended sliding-section rod to close on the run, by permitting the upper section to drop, may jar the vernier scale out of position or otherwise damage the rod. Always close an extended rod by easing the upper section down gradually.

A rod will read accurately only if it is perfectly straight. It follows, then, that anything that might bend or warp the rod must be avoided. Do not lay a rod down flat unless it is supported throughout, and never use a rod for a seat, a lever, or a pole vault. In short, never use a rod for any purpose except the one for which it is designed.

Store a rod not in use in a dry place to avoid warping and swelling caused by dampness. AI ways wipe off a wet rod before putting it away. If there is dirt on the rod, rinse it off, but do not scrub it off. If a soap solution must be used (to remove grease, for example), make it a very mild one. The use of a strong soap solution will soon cause the paint on the rod to degenerate.

Protect a rod as much as possible against prolonged exposure to strong sunlight. Such exposure causes paint to chalk (that is, degenerate into a chalk-like substance that flakes from the surface).

DIFFERENTIAL LEVELING

LEARNING OBJECTIVE: Upon completing this section, you should be able to determine elevations in the field to locate points at specified elevations.

The most common procedure for determining elevations in the field, or for locating points at specified elevations, is known as differential leveling. This procedure, as its name implies, is nothing more than finding the vertical difference between the known or assumed elevation of a bench mark and the elevation of the point in question. Once the difference is measured, it can (depending on the circumstances) be added to or subtracted from the bench mark elevation to determine the elevation of the new point.

ELEVATION AND REFERENCE

The elevation of any object is its vertical distance above or below an established height on the earth's surface. This established height is referred to as either a "reference plane" or "simple reference." The most commonly used reference plane for elevations is mean (or average) sea level, which has been assigned an assumed elevation of 000.0 feet. However, the reference plane for a construction project is usually the height of some permanent or semipermanent object in the immediate vicinity, such as the rim of a manhole cover, a rod, or the finish floor of an existing structure. This object may be given its relative sea level elevation (if it is known); or it may be given a convenient, arbitrarily assumed elevation, usually a whole number, such as 100.0 feet. An object of this type, with a given, known, or assumed elevation, which is to be used in determining the elevations of other points, is called a bench mark.

PRINCIPLES OF DIFFERENTIAL LEVELING

Figure 5-15 illustrates the principle of differential leveling. The instrument shown in the center represents an engineer's level. This optical instrument provides a perfectly level line of sight through a telescope, which can be trained in any direction. Point A in the figure is a bench mark (it could be a concrete monument, a wooden stake, a sidewalk curb, or any other object) having a known elevation of 365.01 feet. Point B is a ground surface point whose elevation is desired.

The first step in finding the elevation point of point B is to determine the elevation of the line of sight of the instrument. This is known as the height of instrument and is often written and referred to simply as "H.I." To determine the H.I., you take a backsight on a level rod held vertically on the bench mark (B.M.) by a rodman. A backsight (B.S.) is always taken after a new instrument position is set up by sighting back to a known elevation to get the new H.I. A leveling rod is graduated upward in feet, from 0 at its base, with appropriate subdivisions in feet.

In figure 5-15, the backsight reading is 11.56 feet. Thus, the elevation of the line of sight (that is, the H.I.) must be 11.56 feet greater than the bench mark elevation, point A. Therefore, the H.I. is 365.01 feet plus 11.56 feet, or 376.57 feet as indicated.

Next, you train the instrument ahead on another rod (or more likely, on the same rod carried ahead) held vertically on B. This is known as taking a foresight. After reading a foresight (F.S.) of 1.42 feet on the rod, it follows that the elevation at point B must be 1.42 feet lower than the H.I. Therefore, the elevation of point B is 376.57 feet minus 1,42 feet, or 375.15 feet.

GRADING

The term "grade" is used in several different senses in construction. In one sense, it refers to the steepness of a slope; for example, a slope that rises 3 vertical feet for every 100 horizontal feet has a grade of 3 percent. Although the term "grade" is commonly used in this sense, the more accurate term for indicating steepness of slope is "gradient."

In another sense, the term "grade" simply means surface. On a wall section, for example, the line that

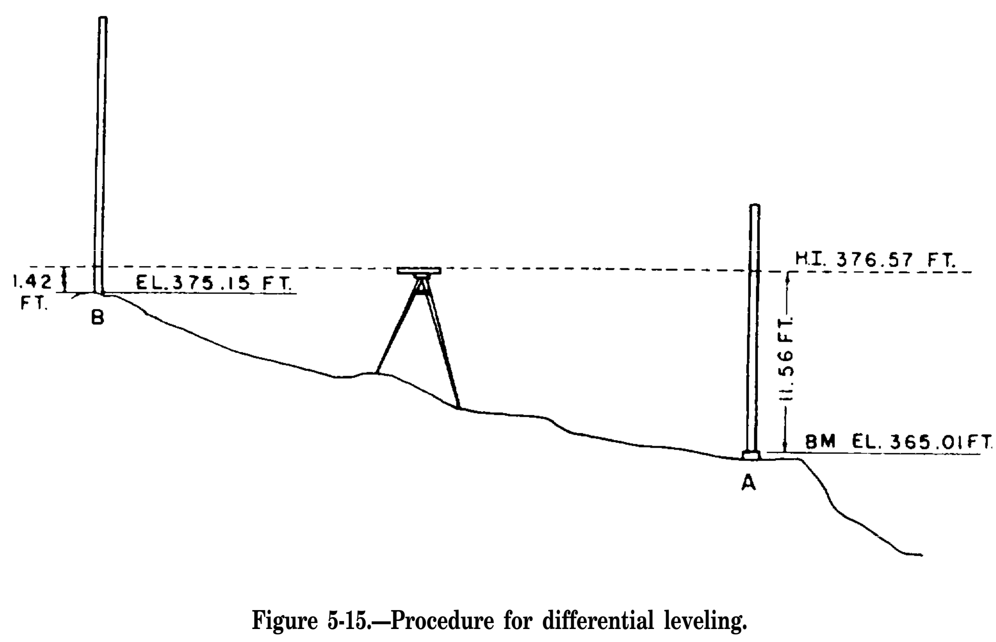

Figure 5-15.—Procedure for differential leveling.

indicates the ground surface level outside the building is marked "Grade" or "Grade Line."

The elevation of a surface at a particular point is a grade elevation. A grade elevation may refer to an existing, natural earth surface or to a hub or stake used as a reference point, in which case the elevation is that of existing grade or existing ground. It may also refer to a proposed surface to be created artificially, in which case the elevation is that of prescribed grade, plan grade, or finished grade.

Grade elevations of the surface area around a structure are indicated on the plot plan. Because a natural earth surface is usually irregular in contour, existing grade elevations on such a surface are indicated by contour lines on the plot plan; that is, by lines that indicate points of equal elevation on the ground. Contour lines that indicate existing grade are usually made dotted; however, existing contour lines on maps are sometimes represented by solid lines. If the prescribed surface to be created artificially will be other than a horizontal-plane surface, prescribed grade elevations will be indicated on the plot plan by solid contour lines.

On a level, horizontal-plane surface, the elevation is the same at all points. Grade elevation of a surface of this kind cannot be indicated by contour lines because each contour line indicates an elevation different from that of each other contour line. Therefore, a prescribed level surface area, to be artificially created, is indicated on the plot plan by outlining the area and inscribing inside the outline the prescribed elevation, such as "First floor elevation 127.50 feet."

BUILDING LAYOUT

LEARNING OBJECTIVE: Upon completing this section, you should be able to determine boundaries of building layout.

Before foundation and footing excavation for a building can begin, the building lines must be laid out to determine the boundaries of the excavations. Points shown on the plot plan, such as building corners, are located at the site from a system of horizontal control points established by the battalion engineering aids. This system consists of a framework of stakes, driven pipes, or other markers located at points of known horizontal location. A point in the structure, such as a building corner, is located on the ground by reference to one or more nearby horizontal control points.

We cannot describe here all the methods of locating a point with reference to a horizontal control point of a known horizontal location. We will take, as an illustrative example, the situation shown in figure 5-16. This figure shows two horizontal control points, consisting of monuments A and B. The term "monument," incidentally, doesn't necessarily mean an elaborate stone or concrete structure. In structural horizontal control, it simply means any permanently located object, either artificial (such as a driven length of pipe) or natural (such as a tree) of known horizontal location.

In figure 5-16, the straight line from A to B is a control base line from which the building corners of the structure can be located. Corner E, for example, can be located by first measuring 15 feet along the base line from A to locate point C; then measuring off 35 feet on CE, laid off at 90° to (that is, perpendicular to) AB. By extending CE another 20 feet, you can locate building corner F. Corners G and H can be similarly located along a perpendicular run from point D, which is itself located by measuring 55 feet along the base line from A.

PERPENDICULAR BY PYTHAGOREAN THEOREM

The easiest and most accurate way to locate points on a line or to turn a given angle, such as 90°,

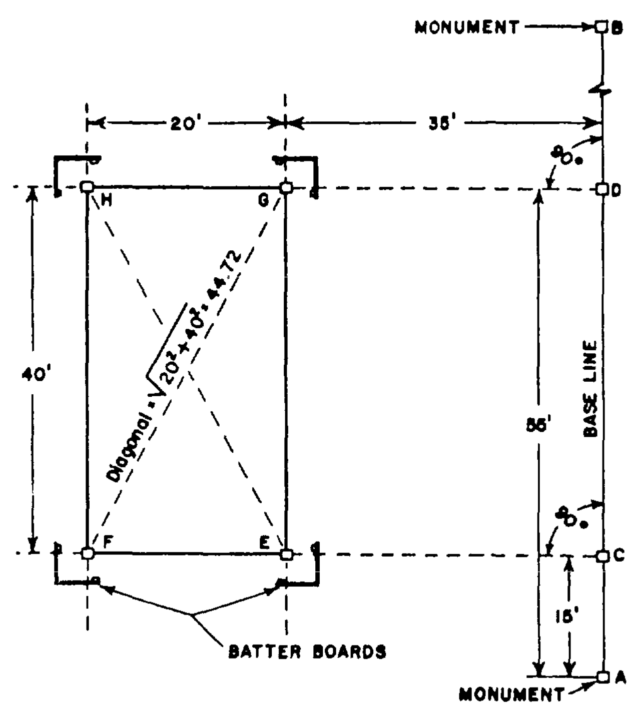

Figure 5-16.—Locating building corners.

from one line to another is to use a surveying instrument called a transit. However, if you do not have a transit, you can locate the corner points with tape measurements by applying the Pythagorean theorem. First, stretch a cord from monument A to monument B, and locate points C and D by tape measurements from A. Now, if you examine figure 5-16, you will observe that straight lines connecting points C, D, and E form a right triangle with one side 40 feet long and the adjacent side 35 feet long. By the Pythagorean theorem, the length of the hypotenuse of this triangle (the line ED) is equal the square root of 35^2+40^2, which is approximately 53.1 feet. Because figure EG DC is a rectangle, the diagonals both ways (ED and CG) are equal. Therefore, the line from C to G should also measure 53.1 feet. If you have one person hold the 53. 1-foot mark of a tape on D, have another hold the 35-foot mark of another tape on C, and have a third person walk away with the joined 0-foot ends, when the tapes come taut, the joined 0-foot ends will lie on the correct location for point E. The same procedure, but this time with the 53. 1-foot length of tape running from C and the 35-foot length ruining from D, will locate corner point G. Corner points F and H can be located by the same process, or by extending CE and DG 20 feet.

PERPENDICULAR BY 3:4:5 TRIANGLE

If you would rather avoid the square root calculations required in the Pythagorean theorem method, you can apply the basic fact that any triangle with sides in the proportions of 3:4:5 is a right triangle. In locating point E, you know that this point lies 35 feet from C on a line perpendicular to the base line. You also know that a triangle with sides 30 and 40 feet long and a hypotenuse 50 feet long is a right triangle.

To get the 40-foot side, you measure off 40 feet from C along the base line; in figure 5-16, the segment from C to D happens to measure 40 feet. Now, if you run a 50-foot tape from D and a 30-foot tape from C, the joined ends will lie on a line perpendicular from the base line, 30 feet from C. Drive a hub at this point, and extend the line to E (5 more feet) by stretching a cord from C across the mark on the hub.

BATTER BOARDS

Hubs driven at the exact locations of building corners will be disturbed as soon as the excavation for the foundation begins. To preserve the corner locations, and also to provide a reference for measurement down to the prescribed elevations, batter boards are erected as shown in figure 5-17.

Each pair of boards is nailed to three 2-by-4 corner stakes as shown. The stakes are driven far enough outside the building lines so that they will not be disturbed during excavation. The top edges of the boards are located at a specific elevation, usually some convenient number of whole feet above a significant prescribed elevation, such as that at the top of the foundation. Cords located directly over the lines through corner hubs, placed by holding plumb bobs on the hubs, are nailed to the batter boards. Figure 5-17 shows how a corner point can be located in the excavation by dropping a plumb bob from the point of intersection between two cords.

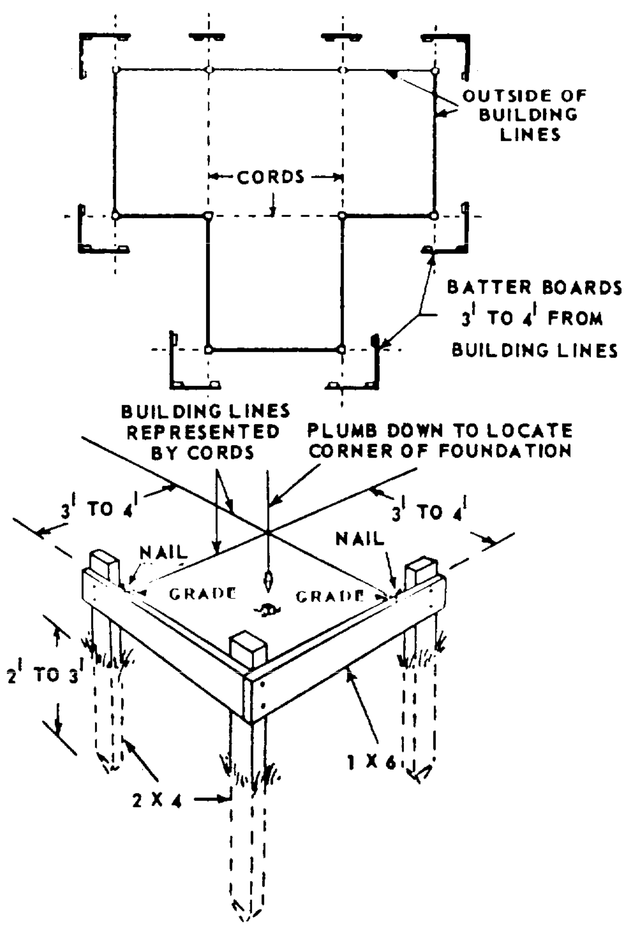

Figure 5-17.—Batter boards.

In addition to their function in horizontal control, batter boards are also used for vertical control. The top edge of a batter board is placed at a specific elevation. Elevations of features in the structure, such as foundations and floors, can be located by measuring downward or upward from the cords stretched between the batter boards.

You should always make sure that you have complete information as to exactly what lines and elevations are indicated by the batter boards. You should emphasize to your crewmembers that they exercise extreme caution while working around batter boards. If the boards are damaged or moved, additional work will be required to replace them and to relocate reference points.

RECOMMENDED READING LIST

NOTE

Although the following reference was current when this TRAMAN was published, its continued currency cannot be assured. You therefore need to ensure that you are studying the latest revision.

Engineering Aid 3 & 2, Vol. 3, NAVEDTRA 10629-1, Naval Education and Training Program Management Support Activity, Pensacola, Fla., 1987.