How To Use

berger

Builder's Transits and Levels

...for faster and more accurate building

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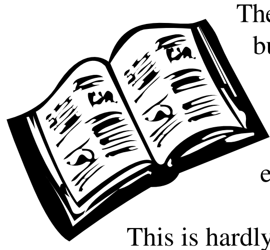
How do you measure the height of an inaccessible object like an overhead floor, beam, or lintel? What's a fast, accurate way of setting a grade line for a sewer...laying out a tennis court...determining the difference in elevation from more than one setup?

These are a few of the practical, everyday surveying jobs clearly diagrammed and explained in this handy "How-to-do-it" booklet. We hope you find it helpful and that the ideas and instruments in it will save you time and money on your next job.

What is surveying, anyway?



The dictionary will give you an excellent definition, of course, but unfortunately it comes out something like this:

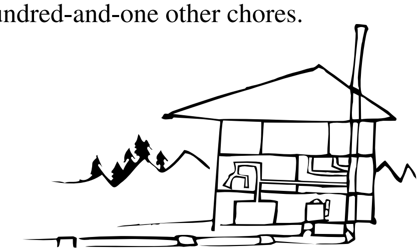
SURVEY (sur-va): To determine and delineate the form, extent, position, etc. of, as a tract of land, by taking linear and angular measurements.

This is hardly designed to encourage you. So let's see what surveying means, not in the engineer's language, but in practical builder's terms.

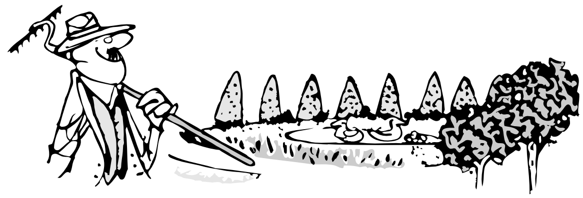
To the builder, surveying primarily means ACCURATE MEASUREMENT. More accurate than he can get with a string, an ordinary compass, protractor or carpenter's level. When you use a Berger instrument, you have the comfortable assurance that the house won't wind up with two inches overlapping on someone else's property line.

Who uses Berger Instruments?
The Builder and Contractor

A Berger helps locate a house properly on a lot, level the foundation, establish grades, run drainage and sewer lines, plumb walls, and do a hundred-and-one other chores.

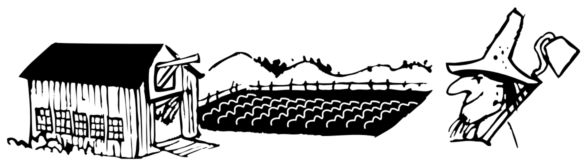


The Landscape Gardener:



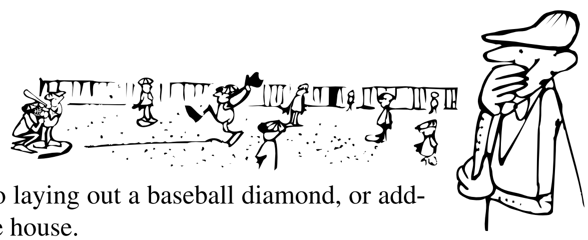
Sets grades and elevations, aligns fences, and establishes rows of shrubbery and trees.

The Farmer:



He uses a Berger to set straight crop rows, determine lines and grades for contour farming, align stone walls, lay agricultural tile, and for all types of building.

Handy Men and Advanced Do-It-Yourselfers:



Use it for everything from building a chicken coop to laying out a baseball diamond, or adding an extra room onto the house.

Now let's take a close-up look at the instruments themselves–and explore the two basic types of builders instruments.

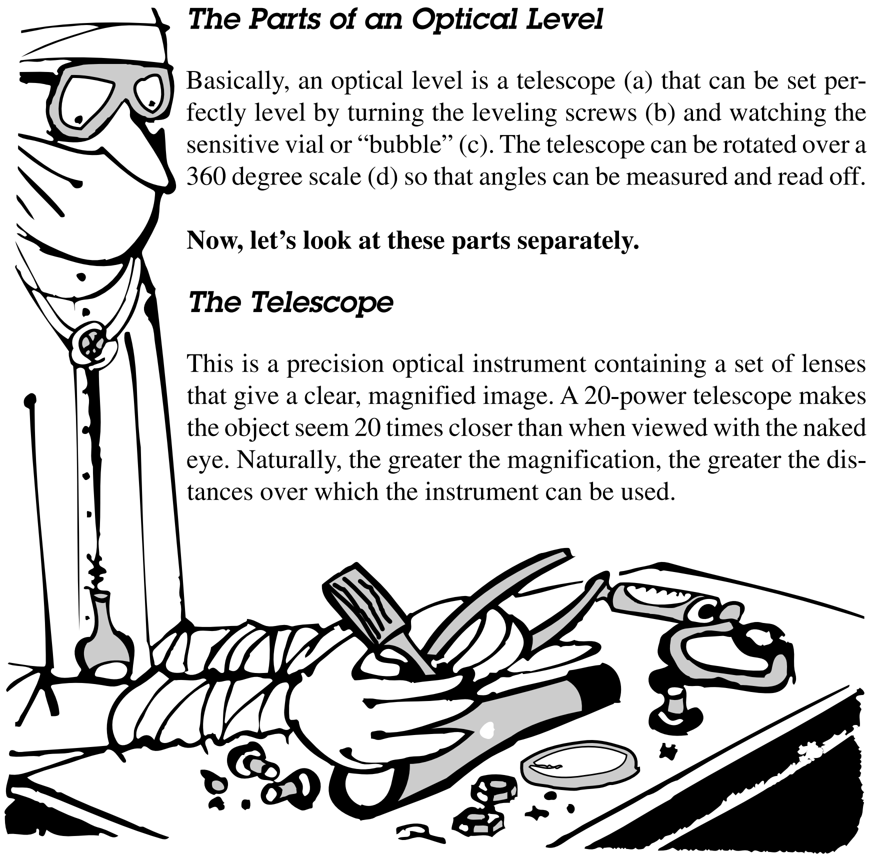
The Optical Level

(Sometimes called the Dumpy Level)

This instrument has its telescope fixed in a horizontal position. The telescope turns sideways for measuring horizontal angles, but cannot be tilted up and down. The Berger levels are the.....

The Transit-Level

This instrument is a combination instrument. The telescope turns not only sideways, but also up and down. This valuable feature enables you to determine if a wall is perfectly plumb, to run straight lines, and to measure vertical angles. Berger transit-levels are......



The Parts of an Optical Level

Basically, an optical level is a telescope (a) that can be set perfectly level by turning the leveling screws (b) and watching the sensitive vial or "bubble" (c). The telescope can be rotated over a 360 degree scale (d) so that angles can be measured and read off.

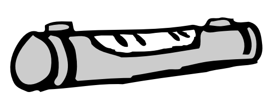
Now, let's look at these parts separately.

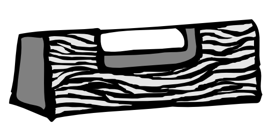
The Telescope

This is a precision optical instrument containing a set of lenses that give a clear, magnified image. A 20-power telescope makes the object seem 20 times closer than when viewed with the naked eye. Naturally, the greater the magnification, the greater the distances over which the instrument can be used.

When you look into the telescope, you see cross hairs like this enabling you to center your target properly. When you look through a Berger telescope, the first thing you'll notice is the remarkable brilliance of the image. The Berger optical system is unequalled. Coated, highly corrected lenses enable you to see greater distances with startling clarity.

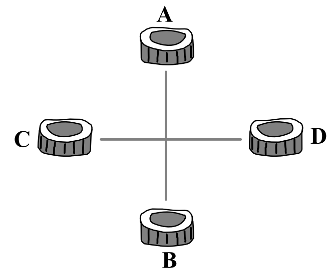
The Leveling Vial





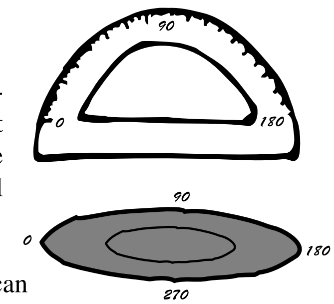
Before you line up the telescope, you must level the instrument by means of the leveling vial and the leveling screws. The vial is located on the telescope itself. It works much the same as the bubble on an ordinary carpenter's level except that it is many times more sensitive, hence many times more accurate. Berger leveling vials are made to the highest standards in the industry.

The Leveling Screws



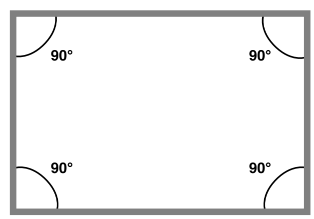
By turning screws A and B, and watching the bubble carefully, we can level up the instrument on the A/B axis. Then we give the telescope a quarter turn to the C/D axis and level the instrument again. After rechecking again over each position, we can turn the telescope around the complete 360 degree circle and be assured that it is level in every direction.

The Circle



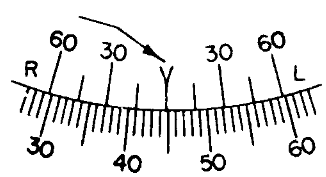
The circle is nothing more nor less than a protractor, similar to the ones used in school, except that it makes a complete 360 degree circle instead of the 180 degree half-circle you'll find on most school protractors.

The circle, or in some cases, the index (pointer) can be rotated independently so that it can be set at zero, no matter which way the instrument is pointing. Starting at zero, and rotating the telescope on it, we can now measure any horizontal angle.



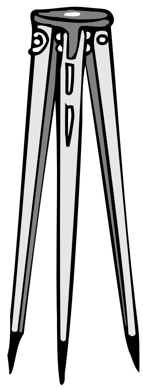
For instance, the foundation for a house shaped like this has a 90 degree angle in each corner.

90 degrees happens to be the most common angle in construction work. Therefore, we have divided the circle into four equal parts (or quadrants) to make it easy to "turn" the telescope over this angle quickly and accurately.



For greater accuracy in measuring angles, some instruments are also equipped with Vernier Scales. A Vernier Scale allows us to measure in minutes (there are 60 minutes in each degree). Such accuracy is especially important when we are sighting over long distances, or engaged in precision construction.

And speaking of accuracy, the graduations on Berger transit circles are marked out by special machines that are unusually accurate; another reason why a Berger is a more dependable instrument.



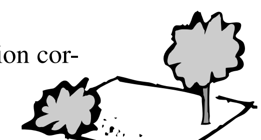
The Tripod

Just as the foundation supports the house, the tripod supports the instrument. Each Berger instrument comes equipped with a rugged tripod. Steel tips on the shoes insure longer wear. And, tripod shoes are equipped with sturdy spurs which allow you to push the tripod legs into the ground to insure even firmer footing.

Now let's put a Berger to work...

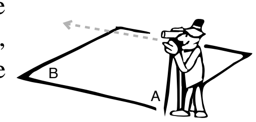
We've already told you how easy it is to use a Berger instrument. And now we're going to prove it.

Let's suppose you are preparing to establish the foundation corner of a house.

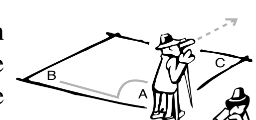


1. You start with this empty lot.

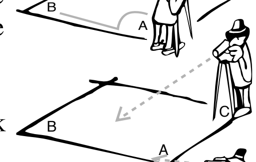
2. You intend to put this rectangular-shaped house on it. Problem: to "square off" the corners of the house accurately.



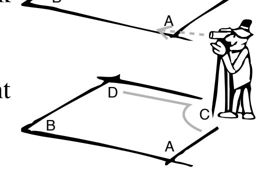
3. Let's assume that we have established the front of the building line–the line from A to B. We must now complete our rectangle. We start by setting up our instrument at A, leveling it up and pointing it toward B. Then we set the circle or pointer to 0 degrees.



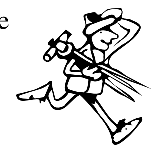
4. Now, we swing our telescope exactly 90 degrees, which establishes the direction of point C. We measure off the correct footage from A to C with a tape and drive in a stake at C.



5. Now, we move our instrument to point C. We sight back on A and set the horizontal circle at zero.



6. Next, we swing our level 90 degrees and establish point D. Tape the length and drive in a stake at D.



7. We have now established our foundation corners. We have a rectangle and the whole thing has been accomplished in a matter of minutes.

Why all points along a line of sight are exactly level...

POINT A POINT B POINT C POINT D ETC...

The line of sight through our telescope is a continuous, perfectly straight line for as far as we can see. It is straight because it is a line without weight and therefore cannot sag, as would be the case with a length of string. Therefore, any point along our line of sight is exactly level with any other point.

The following is basically from text prepared by Herman J. Shea, former Associate Professor of Surveying, Massachusetts Institute of Technology.

Measuring Difference in Elevation from One Setup

To find the difference of elevation between two points which can be observed from one position, set up and level your instrument about midway between these points. Be sure that a leveling rod held on both opposite points can be read when your telescope is level. Each point should not be greater than 150 to 200 feet away from the instrument or you may have difficulty reading the rods. The height of the line of sight (horizontal crosshair) above or below each of the points is found by reading the rod.

FIG. 1a shows a line of sight 69 inches above A and 40 inches above B. Therefore, B is higher than A by 29 inches.

Suppose one of your points is below the line of sight and the other above, for example, in FIG. 1b, C is 4 feet 6-1/2 inches below the line of sight, and point D, the underside of a floor beam is 7 feet 9-3/8 inches above the line of sight (the latter reading having been obtained by holding the rod upside down with the foot of the rod against the beam). D is then higher than C by an amount equal to 4 feet 6-1/2 inches plus 7 feet 9-3/8 inches, or a total of 12 feet 3-7/8 inches.

Measuring the Difference in Elevation Requiring More Than One Setup

If two points are either too far apart or at too great a difference of elevation to be observed from one setup, the procedure shown in FIG. 2 is recommended. This example assumes that you want to find the difference in elevation between points A and D. To make the finding of this difference simple, use the convenient terms **plus (+) sight** and **minus (–) sight** and carry the readings at each setup as shown.

The difference of elevation between D and A is found by taking the difference between the sum of the plus sights and the sum of the minus sights. If the sum of the plus sights is larger, the final point is **higher** than the starting point. If the sum of the minus sights is larger, the final point is **lower** than the starting point.

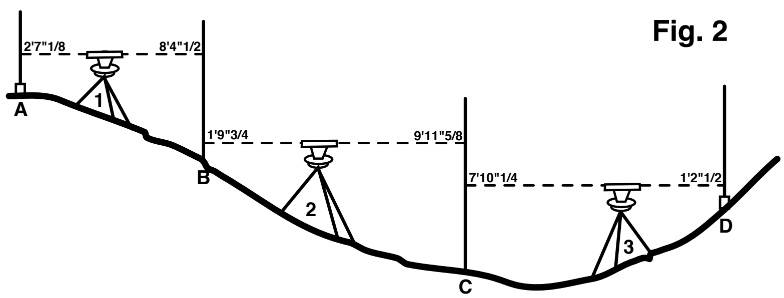


Fig. 2

Elevations or Grades

Many constructions, such as buildings and roadways, are required to be built at specified elevations or grades. To establish these grades, a point of elevation is necessary, often called a **benchmark**. Your benchmark should be a firm and definite point such as a bolt on a water hydrant, a spike in the root of a tree, a corner of a stone monument, or a chisel square on a ledge, and should be located **outside** the construction area. For a large job, several benchmarks in convenient locations are helpful. The grades may then be carried directly to the job by using the “difference in elevation” method described above (see FIG. 1 and FIG. 2).

Profile Leveling

Profiles are required for the study and construction of highways, railways, sewers, water pipes, gas pipes, curbs, electric power lines, canals, drainage, flood control, and many more like projects. Most of the projects described are laid out as a series of straight lines or nearly straight lines. Profile leveling is for the purpose of determining the elevations of the ground surface along a center line (or some other similar line) for one of the “jobs”.

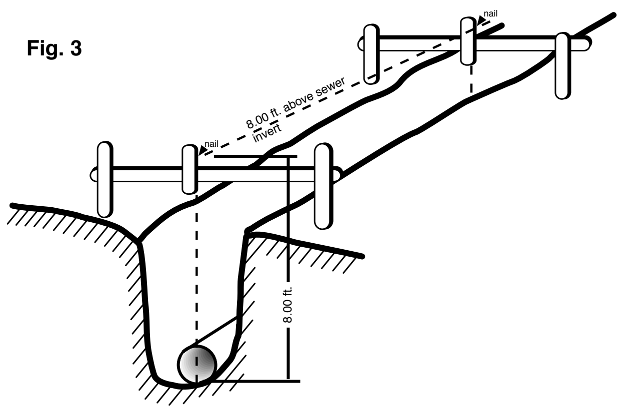
Grade Rod

When it is necessary to set a point at some definite elevation, set up the instrument near the point to be set. The elevation of the instrument (E.I.) is determined. What the rod must read, so that the base of the rod is at the desired grade, is called the grade rod. The grade rod is calculated by subtracting the grade from the elevation of the instrument (E.I.). The rodman raises or lowers the whole rod, at the direction of the instrument man, until the grade rod reading is read on the rod. The base on the rod is then at the desired grade. A pencil or crayon mark drawn at the base of the rod upon a stake or some similar object, will preserve the desired grade.

Batter Boards for a Sewer

Sewers are normally placed at some depth below the surface of the ground, so batter boards are placed somewhat higher above the invert grade. FIG. 3 shows a typical layout for sewer batter boards. The vertical strip nailed to the horizontal board is set with one edge along the line of the sewer. A nail is placed in this vertical strip at an even number of feet above the invert. By stretching a taut line between these nails, the sewer line is easily referenced. A board notched say 8 feet from its bottom is used to set the pipe.

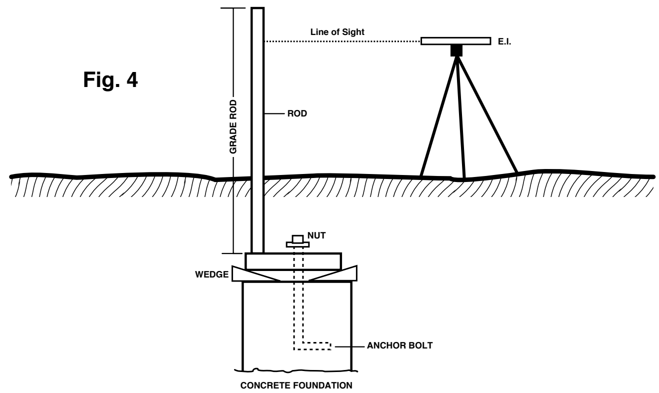
Fig. 3



Setting Base Plates

For bridges and large buildings, base plates must be accurately set (FIG. 4). The concrete pier or foundation is poured slightly below grade. Four wedges, one at each corner, are placed upon the concrete foundation, and the base plate is lowered in place resting on the wedges. The grade rod is calculated and the rod is placed on one corner. The wedge at that corner is slowly driven until the correct grade and reading is obtained. This procedure is repeated at the other three corners. The four corners should then be checked for any displacement that may have occurred. When checked, the space between the top of the foundation and the bottom of the base plate is filled with concrete grout.

Fig. 4



SETTING BASE PLATES

Measuring Horizontal Angles

To measure horizontal angles such as EFG, FIG. 5, center and level your instrument over point F; rotate the instrument until point E is in line with the vertical crosshair and set the horizontal circle to read zero (on some instruments, rotate the circle; on other instruments, set to zero with movable index). Now swing the telescope toward point G until the vertical crosshair is exactly on point G. The horizontal index pointer will have rotated about the horizontal circle by an amount equal to the angle EFG. If your instrument is furnished with a vernier instead of an index pointer, you will be able to read the angle closer than a single degree.

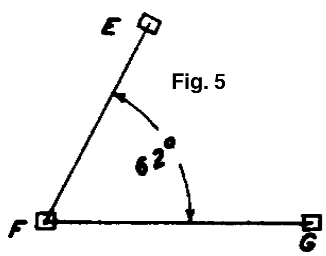


Fig. 5

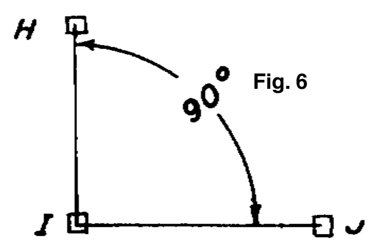


Fig. 6

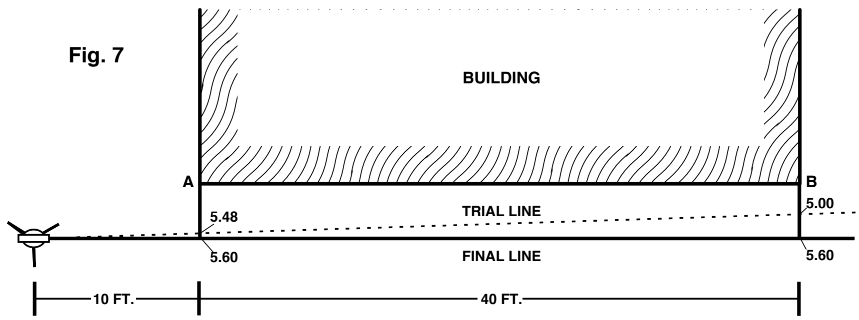
To Lay Out a Horizontal Angle

In layout work, it is frequently necessary to set off an angle, usually 90°. In FIG. 6, assume that the 90° angle HIJ is to be laid off and points H and I are known. Therefore, J is the point you are to set. Center and level your instrument over point I. Sight the telescope on point H and set the horizontal circle to read 0°. Rotate the telescope until the index pointer reads exactly 90°. The line of sight (vertical crosshair) will indicate point J and all you have to do is to set J along the line of sight by taping the required distance from I.

To Establish an Offset Line

Often when surveying around buildings, it is often necessary to take measurements relative to an existing building. The instrument cannot be set up at the building corner, so some other method must be used. By working with offset lines which are parallel to the building sides, many of the problems can be solved.

Fig. 7



To establish a line parallel to a building, proceed as follows. Set a line of sight parallel to the building by estimation as closely as possible (trial line, FIG. 7). By swinging a tape or rod held horizontally at the building corners, the distance from the trial line of sight to the building is read directly by noting the **minimum** reading. This operation is called taking a **swing offset**.

In FIG. 7, by swinging a rod pivoted at corner A, a minimum rod reading of 5.48 feet was noted; by swinging about corner B, a minimum of 5.00 was read. Obviously the trial line of sight is inclined in toward the building and must be moved outward. New trial lines may be tried until the swing offsets are the same. In this example, the correct figure for the swing offset is found as follows.

Note the difference between the swing offsets (0.48 ft.). Divide the distance between corners (40 ft.) by the distance from the instrument to the first corner (10 ft.). Next, divide the difference between readings (0.48 ft.) by this result (4). Add this answer (0.12 ft.) to the swing offset reading at the nearest corner (5.48 ft. + 0.12 ft. = 5.60 ft.). This is the correct swing offset reading.

Offset Grade Stakes for a Driveway

When setting grade stakes for a driveway, place the grade stakes on both sides of the driveway as in FIG. 8 (usually at equal distances from the centerline) on which the grades of the driveway are indicated. Assume that the rod reading for this driveway at this section is 4 feet 10 inches. Grade stakes A and B are set at equal distances from the centerline. In marking grades on A and B, mark an even number of feet of either grade, or a cut or fill. Any convenient reading, so that the bottom of

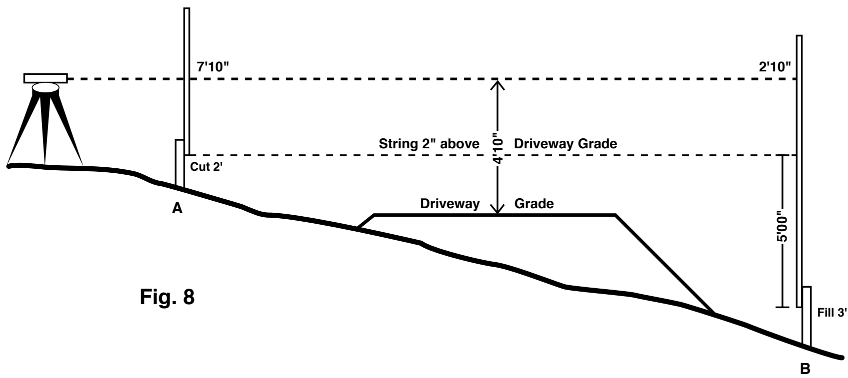


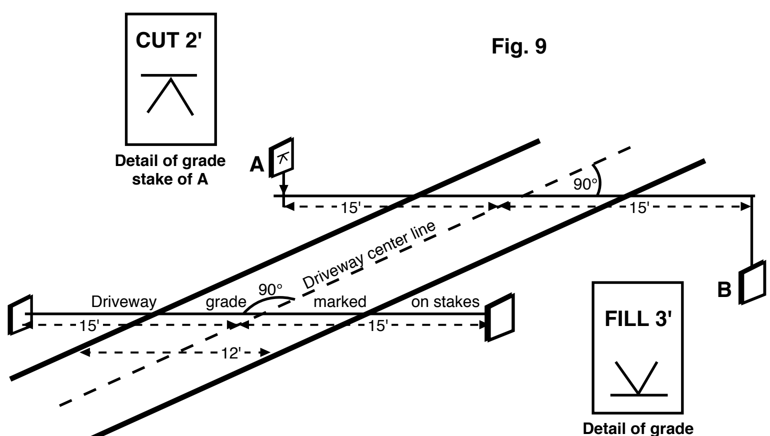
Fig. 8

the rod is somewhere along the stake, is used to note the grade. At A, for example, a rod reading of 2 feet 10 inches is obtained. A line is placed on the grade stake. This line represents a cut of two feet and in marked as in FIG. 9.

In a similar manner, a rod reading of 7 feet 10 inches is found at B. This is marked as a fill of 3 feet according to FIG. 9.

To use these grade stakes, a line is stretched from the marking at A to a point 5 feet above the marking at B. This line then indicates 2 feet above the driveway grade.

Fig. 9



Let's Look at the Uses for a Transit-Level

Because the telescope of a transit-level can be tilted up and down, it extends the versatility of the instrument. For instance:

Setting Points in Line

In FIG. 10, points A and B are two points which are on a line such as a property boundary. When erecting a fence, additional points between A and B and also on the other side of B from A may be needed. Center and level your instrument over point A; sight on point B. Depress the telescope to set points between A and B on line.

If the top of a stake cannot be seen, when you come to set point C, sight with the aid of a plumb bob: first, to find where to drive the stake, and secondly, to note the point on the top of the stake.

If it is necessary to continue this line beyond point C, center and level your instrument over point B, sight point C and continue this procedure.

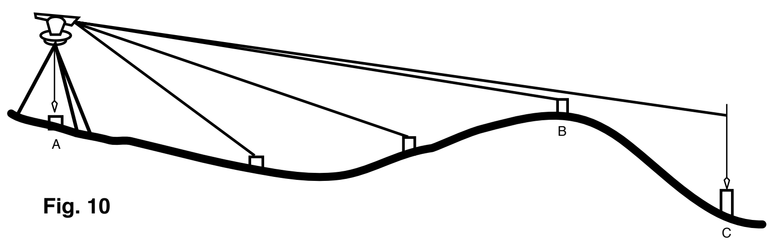


Fig. 10

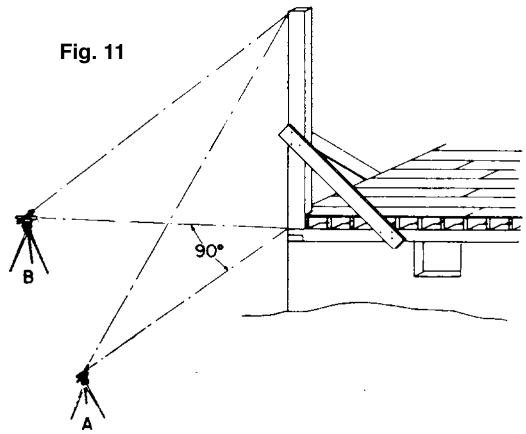
Measuring Vertical Angles

The vertical arc attached to the telescope measures vertical angles above or below the horizontal. By use of the telescope clamp and tangent screw set the horizontal crosshair on the object to which the vertical angle is being measured. Vertical angles are read by means of the index pointer (and vernier, if instrument has one) similar to the reading of horizontal angles.

Plumbing

Instruments of the transit-level type can be used to advantage in plumbing such objects as building walls, columns and flagpoles. Set and level your instrument at a point which is about as far away from the object as the object is tall. Select a point at the base of the object which is to be plumbed; sight your telescope on this point and set the intersection of cross wires directly on it. By raising your telescope, you will find, through use of the line of sight and the crosshairs, whether or not the object is plumb. If it is plumb, the object will appear not to move away from the crosshair intersection. To completely check the plumb of the object, set the instrument at a position which is at an angle of 90° from the first position of the instrument and repeat the procedure. FIG. 11 shows how a corner post of a wood frame building may be plumbed.

Fig. 11



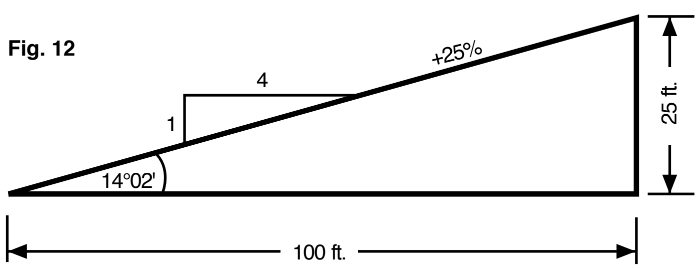
To Plumb a Vertical Column:
At A, sight outside edge of cornerpost at the base. Raise line of sight to top of post. Bring outside edge to line of sight. Nail brace facing instrument. Repeat process at B.

Definitions of Slopes and Grades

In FIG. 12 are shown three different methods by which grades and slopes are specified. They are:

1. Horizontal distance to rise (or fall) in vertical; thus the grade shown in FIG. 12 is 4 to 1, or, more completely, 4 **horizontal** to 1 **vertical**.
2. Rise or fall for each 100 feet horizontal. In FIG. 12, the slope, if extended for 100 feet horizontally would rise 25 feet. This is referred to as a 25% slope.
3. The angle which the slope makes with the horizontal. This is found by taking the percent grade, expressed as a decimal, and finding the angle whose tangent corresponds to the decimal. Tangent angle = 0.25; Angle = 14°2'

Fig. 12



To Stake Out a Grade Line

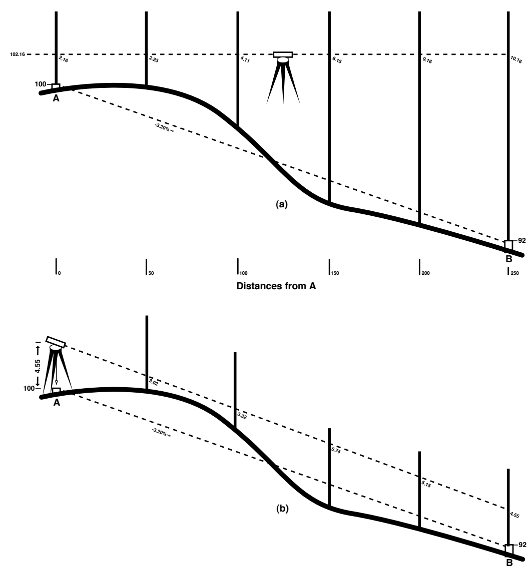
In FIG. 13, a grade line is established as running from the top of a stake at A (elevation 100.00 feet) to the top of a stake at B. The horizontal distance between these points is 250 feet and the difference in elevation is 8.00 feet (10.16 - 2.16 = 8.00 feet). The grade in percent is therefore:

100 x (8.00 ÷ 250) = 3.20%

Since the grade is falling -3.20 percent when looking from A to B, the angle which the grade line makes with the horizontal is found as follows:

Tangent Angle: 0.0320
Angle: 1°50'

Again, if we look from A toward B, the angle should be specified as -1° 50'.



In FIG. 13 (a), data relative to the grade line are determined from elevation of the ground points at each of the 50-foot points. Using the same setup of the transit-level and noting that the elevation of the line of sight is 100.00 + 2.16 = 102.16 feet, the following table may be prepared:

Dist. from A	Grade Elev.	Dist. from A	Grade Elev.
0A	100.00	150	95.20
	-1.60		-1.60
50	98.40	200	93.60
	-1.60		-1.60
100	96.80	250=B	92.00
	-1.60		(CHECK)

It is assumed that information relative to this grade is desired for every 50 feet along the line. The grade at each 50-foot point is found by subtracting 1.60 feet

(3.2 percent ÷ 2) from the grade elevation of the preceding point. The following table shows the necessary calculations:

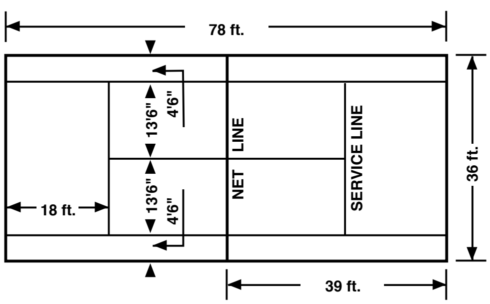
Dist. from A	Rod Reading	Ground Elev.	Grade	Cut	Fill
50	2.23	99.93	98.40	1.53	---
100	4.11	98.05	96.80	1.25	---
150	8.15	94.01	95.20	---	1.19
200	9.16	93.00	93.60	---	0.60

The cuts and fills at these stations indicate what construction must take place in order to set out the grade specified.

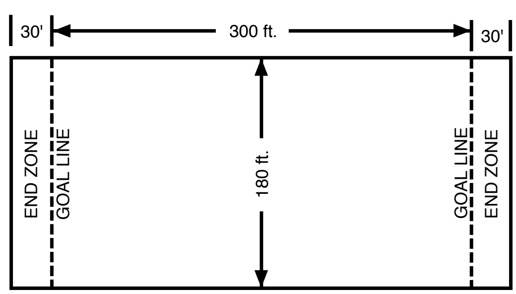
Another method of staking out this grade is through the use of the vertical angle that the grade makes with the horizontal (FIG. 13b). If the transit-level is set up over stake A and the telescope is depressed to read a vertical angle of -1°50', the line of sight will indicate the required grade line. If this height is measured to be 4.55 feet, then a rod reading of 4.55 feet anywhere along the line will indicate that that point is on the desired grade. If the rod reading at a point is less than 4.55 feet, then the ground must be cut; if greater than 4.55 feet, then the ground must be raised or filled.

Athletic Playing Field Layouts

Instruments of both the transit-level and dumpy level type can be used in the layout of athletic fields.



TENNIS COURTS



FOOTBALL FIELD
Goal posts 18'6" apart; cross bar 10' above ground