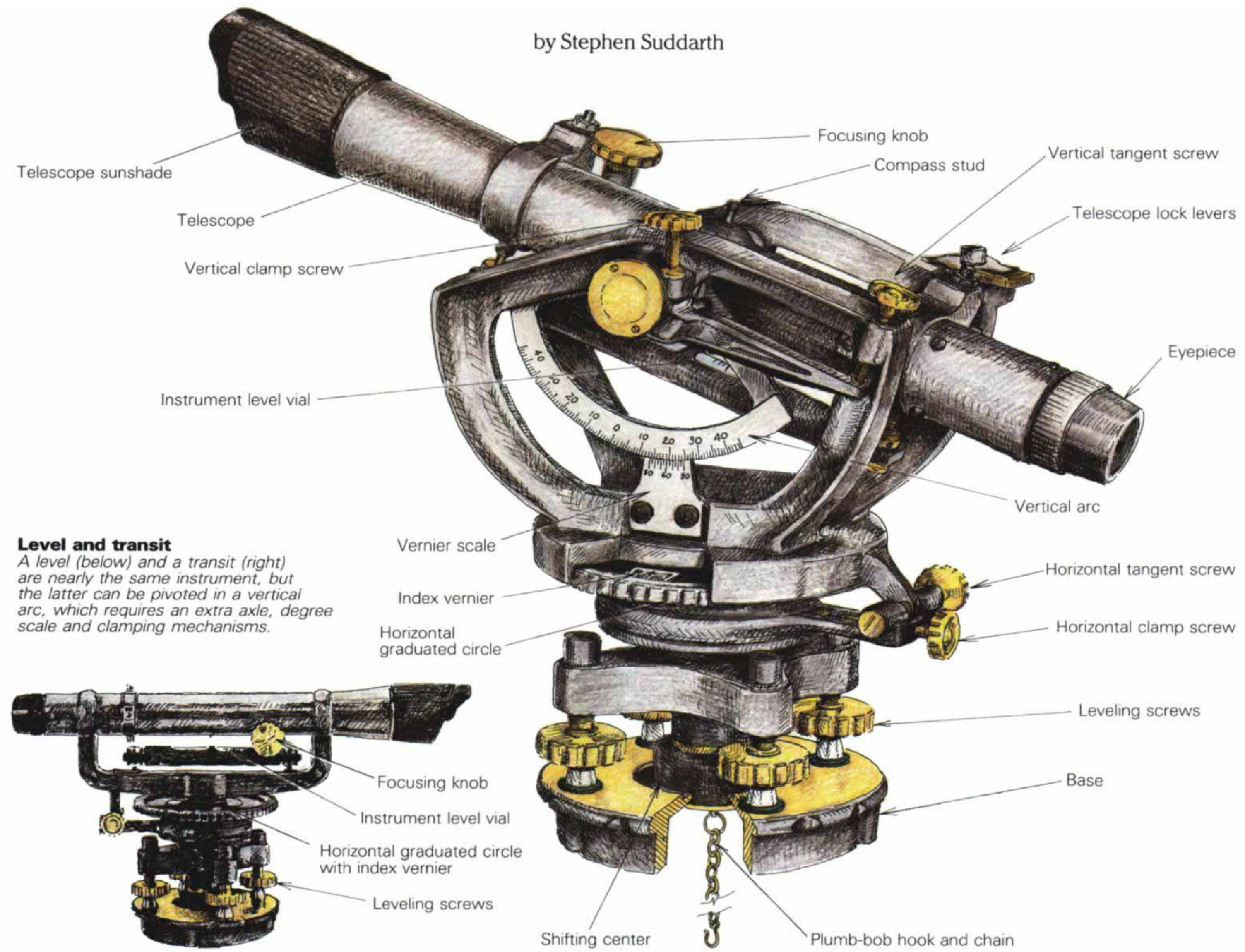
Levels and Transits

Shooting lines and grades involves nothing more than what meets the eye

by Stephen Suddarth



Level and transit
A level (below) and a transit (right) are nearly the same instrument, but the latter can be pivoted in a vertical arc, which requires an extra axle, degree scale and clamping mechanisms.

In all my discussions with skilled tradespeople on building sites, the most common complaint is, "it's not square" or "it's not level." From tile-setters, masons and carpenters to plumbers and welders, it seems that the better the job they're trying to do, the more they like to see accurate work preceding their efforts. That means pin-point layouts in the beginning and follow-up checks as work progresses.

Uncomplicated buildings on level sites can be laid out with simple, inexpensive measuring tools. Water levels, line levels, even spirit levels held against a long straightedge will work to check for plumb and level. And you can put the Pythagorean theorem to work with stringlines and tapes to check for square.

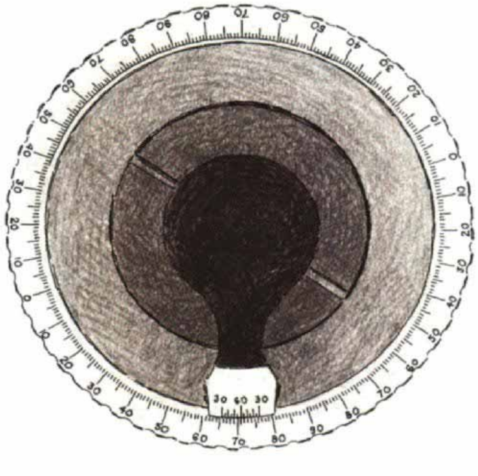
For me though, the right tool for leveling, laying out and double-checking is the builder's transit. Now that I'm used to setting up the instrument, it has become an easy matter to lay out a house, especially if it has more than a simple four-wall shape. Checking the work in progress on walls, floors or columns is also a lot easier if a transit or level is used.

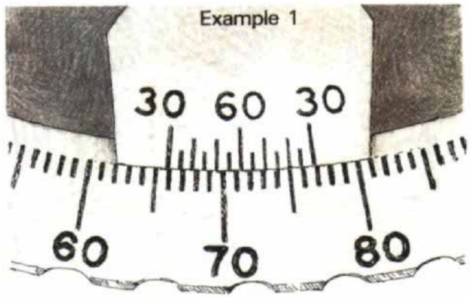
Two instruments—Optical leveling and layout instruments fall into two categories: the level (drawing, above left), and the transit, sometimes called a level-transit or a builder's transit (drawing, above right). Both types are simply telescopes in partnership with an accurate spirit level and a pivoting base mounted on a tripod. They operate on the principle that a line of sight is straight, without sag or curve. When a level is set up correctly, any point along its line of site is at the same level as the instrument's horizontal crosshair. Because it is a telescope, it becomes an extension of your eyesight, giving you the ability to focus on a tape rule or leveling rod from a distance. The vertical crosshair is a reference point that allows you to rotate the scope and lay out any angle in a horizontal plane.

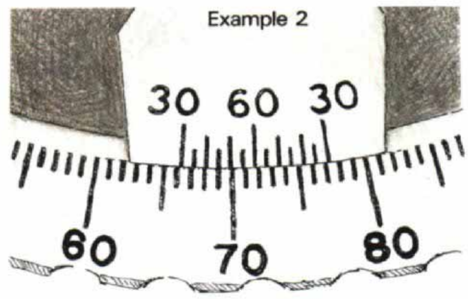
Angle readings are expressed in degrees. They are read off the graduated circle, which is divided into four quadrants of 90° each (top left drawing, next page). The pointer that registers the degree setting is at the center of the vernier, which is an auxiliary scale that slides against a primary scale. It divides the units on the primary scale (degrees) into smaller constituents called minutes (there are 60 minutes in a degree), al-

Drawings: Christopher Clapp

Reading the vernier







Both levels and transits have degree scales that are divided into 90° quadrants. The scale can remain stationary as the instrument rotates, or it can be moved independently. The vernier moves along with the instrument. To read a degree setting, note the position of the center mark on the vernier. Vernier scales vary—on this one the center mark doubles as the 60' (minute) mark and the 0' mark. Readings begin at zero, move to the right to 30', then continue from the 30' mark at the far left to end on 60'. In example 1, the center mark reads slightly more than 71° on the graduated circle. To determine the minute reading, look for the vernier mark that aligns with a degree mark. In this case the 75° mark lines up with the 20' mark, so the setting is 77° 20'. In example 2, the center mark reads a little less than 72°, while the minute mark aligns at 69°. Reading from the left of the vernier, the minutes equal 45, so our setting is 71° 45'.

lowing very precise readings to be made. On my Realist builder's transit, the vernier is divided into five-minute segments.

A transit is essentially a level with an added axle that allows the telescope to pivot up and down in a vertical plane. This makes it possible to "see" in a plumb line by sighting the vertical crosshair while pivoting the scope up or down. This feature is especially helpful when you are aligning tall walls or laying out stakes on a hilly site. The vertical pivot has its own degree scale and vernier. Surveyors use this feature to calculate angles in a vertical plane, which can then be plugged into simple calculations to find the heights and distances of objects. While surveyors use instruments that are similar to a builder's transit, the surveyor's equipment has to work to closer tolerances—about ± 1/10 in. in a mile compared to ± 3/16 in. in 150 ft. for a good builder's transit.

Because of their greater accuracy, surveyors' instruments are a lot more expensive than those made for builders. But some of their fancier features—specifically those that make it easier to set up the instrument—are now being offered by several manufacturers (see the sidebar on laser levels, p. 45). This article is about the traditional instruments, so let's take a look at how to set them up. In some ways, this is the toughest part of using a transit or a level. It takes calm hands, a careful eye and a lot of patience just to get one of these instruments ready to use. But without an impeccable setup, your results will be worthless.

Setup for leveling—To begin, find a fairly flat piece of ground that is centrally located on the site and position the tripod with its legs about the same distance apart (photo facing page). I like to use an adjustable-leg tripod because it makes it easier to get the instrument to a comfortable sighting height. Adjustable legs also make it easier to set up if you're working on a slope. To guard against bumping the tripod out of its position, stabilize its legs by pressing their metal tips firmly into the ground with your foot.

The bracket where the three legs are joined is called the head, and it is topped by a flat plate with a threaded stud or ring through its center that anchors the instrument. When you begin a setup, try to make the head as level as possible by eye as you adjust the legs of the tripod.

Attached to the base of the level or transit is a hook that aligns with the instrument's vertical crosshair. When you set up the instrument over a fixed point, a plumb bob hung from this hook is used to position the instrument directly above the point. The slip knot (drawing, right) makes it easy to adjust the bob up and down.

Next lift the level by its base plate and hand-tighten it firmly onto the tripod head. On some instruments the four leveling screws have to be backed up to allow space for the mounting stud to be fully tightened. Hand-tighten all the leveling screws until they make firm, equal contact with the tripod head. The instrument shouldn't shift around.

Start leveling the instrument by releasing the horizontal clamp screw (drawing previous page) so the instrument can spin easily on its axis. For instruments with four leveling screws, turn the telescope and line it up directly over two of them. By turning the screws uniformly with your thumbs moving toward each other or away from each other you'll actually be tightening one and loosening the other, which maintains the even pressure of the leveling screws and levels the instrument as you watch the bubble below the telescope. If you remember that the bubble will travel in the direction that your left thumb moves it will probably make this part of the operation easier.

When the bubble is centered over the first pair of screws turn the telescope 90°, directly over the other pair, and repeat the leveling operation. Go back and recheck the first pair of screws—it's not uncommon to have the bubble go out a little on this first check. Adjust if necessary and recheck both again. The test is to turn the telescope in a complete 360° circle and watch the bubble for movement. It should take no longer than about 10 to 15 minutes (automatic levels can be leveled in two to three minutes) to have the bubble in the spirit level centered and not move while the telescope is rotated in a complete 360° circle.

Fixed-point setup—Levels and transits are made to be centered directly over a fixed spot—usually a nail embedded in the top of a stake (photo left), but it may be a mark on the floor or the intersection of two stringlines. In rocky soil I often use rebar for my stakes.

Begin setting up by placing the tripod and the instrument as a unit over the fixed point. Make sure the plumb-bob chain and hook are hanging freely through the tripod head (they are in a plumb line with the exact center, or vertical crosshair, of the instrument). Using a slip knot (bottom drawing, facing page), hang a plumb bob from the hook. Eventually, you'll want the point of the plumb bob between ¼ in. and ½ in. above the fixed point.

What comes next requires practice and patience. The instrument has to be carefully and exactly placed directly over the fixed point with the tripod head eyeballed as level as possible. Back off the leveling screws until the instrument can slide across the tripod head horizontally in any direction. Start with the plumb bob a few inches above the stake because you'll be pressing the tripod legs farther into the ground. You can now move the tripod in small increments by lifting individual legs, moving them in and out or side to side, and then pressing them back into the ground. This operation is easier if you've got someone to steady the plumb bob. While you move the legs about, be sure to keep the tripod head as level as possible.

Once you've got the bob within about ½ in. of the nail, you can slide the instrument across the tripod head until it's centered over the nail and turn the leveling screws until they lightly but firmly support the instrument. If it has a tribrach mounting (three screws), turn the telescope parallel with two of the three leveling screws. As you watch the circular (target) bubble, rotate the screws simultaneously with the thumb and forefinger. As the target bubble approaches center, turn the telescope 90° so it's directly over the third leveling screw. Raise or lower that screw until the bubble is centered. Now rotate the telescope and watch the bubble for movement, and adjust the screws until it remains dead center. Many of the new self-leveling instruments have tribrach mounting, and for most of them you need only get the bubble within the outer circle of the target. Once your setup is complete, do your best to avoid bumping the instrument, and try not even to touch the tripod.

If repeated attempts fail to level the instrument, chances are the spirit-level vial is out of adjustment. If the bubble is off-center the same amount in all positions, it's possible that the line-of-sight adjustment is off. In that case you'll always be sighting higher or lower than actual level. These two conditions are the most common instrument problems. Although some owner's manuals give instructions for adjusting vials, I don't attempt to adjust my own instruments. I send them back to a factory-authorized dealer.

Setting up the tripod. **Begin setting up a level or a transit over a fixed reference point, such as a stake, by spreading the tripod legs equally and pressing their tips into the ground. As you position the tripod legs, watch the instrument—you want it eventually to end up above the stake.**

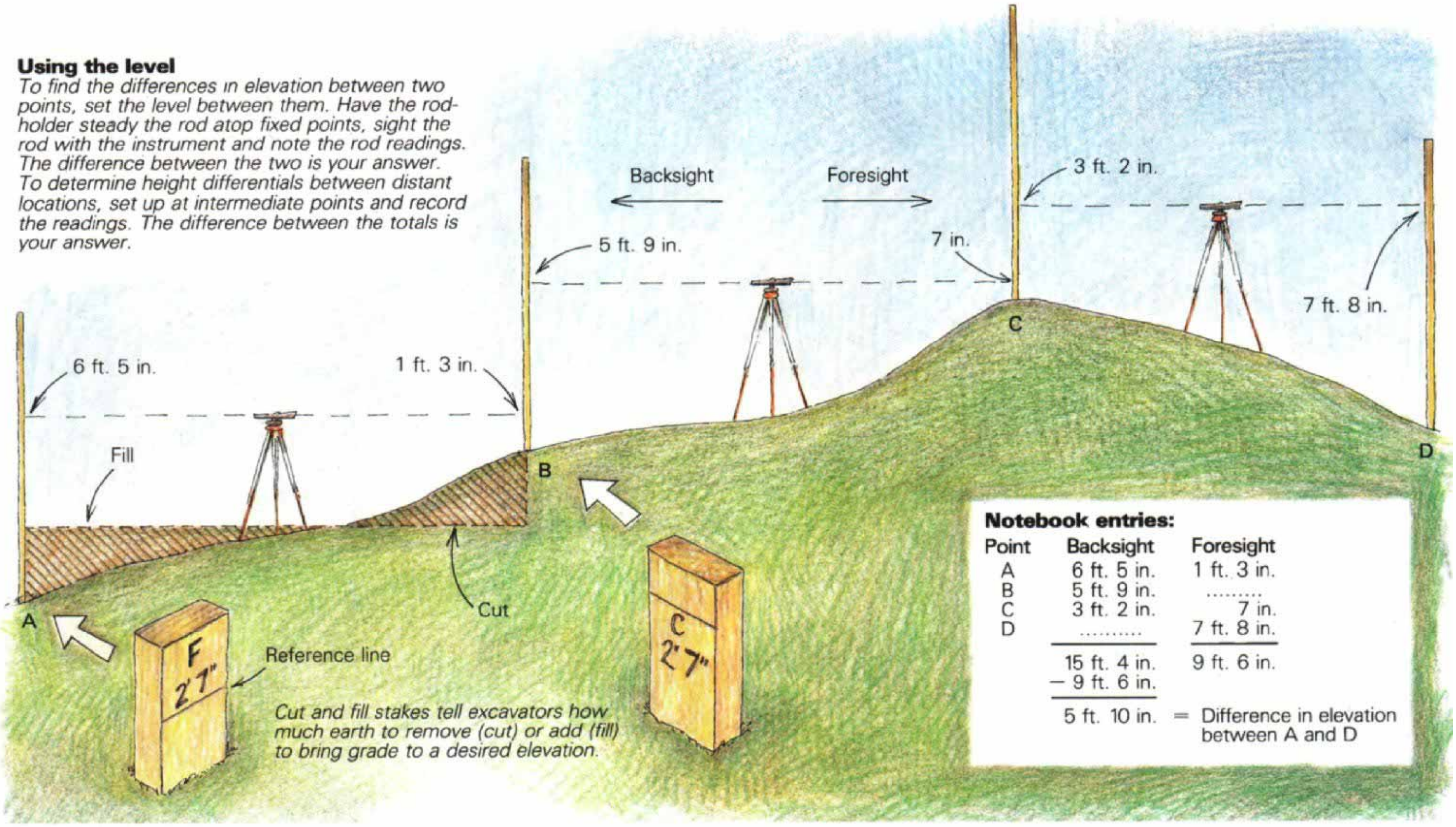
Orientation—It helps to be familiar with the control knobs (drawings, p. 39) on the level or the transit so you can operate without fumbling for the dials while you're trying to sight a target. First unlock the horizontal clamp so that you can easily rotate the instrument on its base with the touch of a finger. Standing comfortably behind it, sight across the top of the telescope to line up your target. Look into the eyepiece (all sighting should be done with both eyes open), find the target and adjust the focusing knob until the target is sharply defined. Lock the instrument with the horizontal clamp so that the crosshairs are near the target. Now bring the crosshairs into focus by turning the eyepiece. You can fine-tune the crosshair up or down with the horizontal tangent screw. If it's a transit, the vertical tangent screw works exactly the same way to adjust the vertical crosshair to the left or right. The power of the telescope varies with different brands, but all the instruments I've seen have either 20x or 26x telescopes.

Using the level—Using a level is a job for two people. The operator sights through the instrument, while the rod-holder positions a leveling rod. A typical leveling rod is a sturdy, two-piece sliding rule made of maple or fiberglass that extends to 8 ft., 10 ft. or 15 ft. An architect's rod is graduated in feet, inches and eighths, while the engineer's version is in feet, tenths and hundredths. Commercial rods have sliding targets that can be moved up and down the rod for easier sighting. Builders will frequently use folding rules or retractable tapes instead of a rod, or make their own rod from an old tape (see p. 14).

A tape rule from close range (20 ft. to 30 ft.) can appear to have such large graduations that you can get distracted. I suggest that you avoid driving your rod-holder (and yourself) crazy by calling out "up a sixteenth" or "down a thirty-second." For a smooth layout, pick a tolerance that you want to work to and stay with it.

Much of a builder's work requires accurate knowledge about the relative heights of objects, or of the elevations of the ground (called grades) around the building site. Suppose, for instance, that you're working on a hill that needs a pad leveled for a parking space, and you need to know the difference in height between the downhill (point A) and the uphill (point B) edges of the pad.

To find the difference, set up the level in a spot roughly between points A and B. Drive a stake flush with the level of the ground at both points to ensure stable reference points that can be relocated. Have your helper hold the rod perfectly plumb on the stake at point A. To get an accurate reading, it helps to have the rod-holder rock the rod slightly toward and away from the instrument. As you sight the rod, the



Using the level

To find the differences in elevation between two points, set the level between them. Have the rod-holder steady the rod atop fixed points, sight the rod with the instrument and note the rod readings. The difference between the two is your answer. To determine height differentials between distant locations, set up at intermediate points and record the readings. The difference between the totals is your answer.

Cut and fill stakes tell excavators how much earth to remove (cut) or add (fill) to bring grade to a desired elevation.

Notebook entries:

Point	Backsight	Foresight
A	6 ft. 5 in.	1 ft. 3 in.
B	5 ft. 9 in.	....
C	3 ft. 2 in.	7 in.
D	....	7 ft. 8 in.
	15 ft. 4 in.	9 ft. 6 in.
	− 9 ft. 6 in.	
	5 ft. 10 in.	= Difference in elevation between A and D

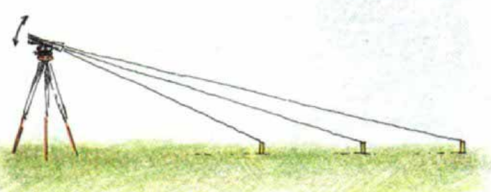
horizontal crosshair reads 6 ft. 5 in. Make a note of this figure, turn the level and sight on the rod held on point B. It reads 1 ft. 3 in. The difference between the two is 5 ft. 2 in., so point B is that much higher than point A (drawing, above).

To level the pad, your equipment operator will need to remove earth from the uphill side and place it on the downhill half to build it up. His reference points are lines drawn on stakes that call for cuts or fills, as shown above. The letter C on the cut stakes and an F on the fill stakes tell him which is which, and the depth of the cut or fill is also written on the stake. In our example, about 2½ ft. of earth (half the difference between the points) has to be cut from the uphill side and compacted on the low side.

You may need to find the difference in elevation between two points that can't be seen from one setup. For instance, finding the heights of point A and point D in the drawing above. In this case, set up the level between intermediate stations and keep notebook entries listing your readings. The backsight column contains measurements taken toward your point of origin, while the foresight measurements are taken toward the destination point. When you are done, add all the numbers in both columns. The difference between the two is your answer.

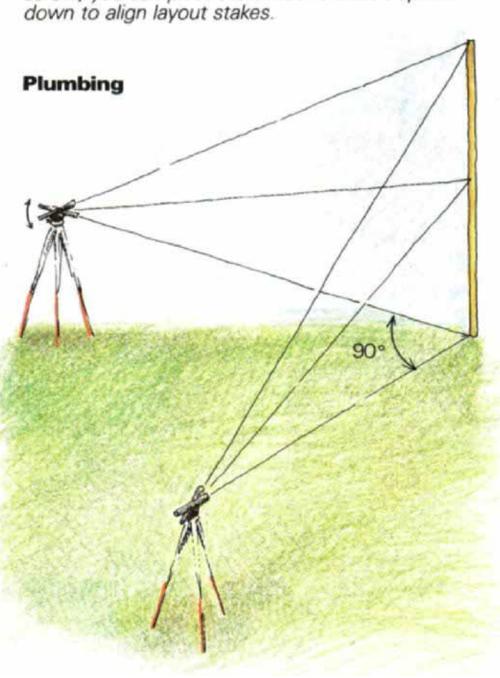
Grade stakes—The great thing about leveling with either the builder's level or the transit is that you can usually set up in a central location and determine the elevation of anything on the site from one place. For instance, here in Florida we usually pour slabs for houses, and sometimes they get pretty big. Without reference points in the middle of the slab, it's possible to get rises and depressions in the slab as much as two or three inches off finished elevation. To

Aligning



By loosening the lever lock and the vertical clamp screw, you can pivot the builder's transit up and down to align layout stakes.

Plumbing



To check for plumb, set the transit's vertical crosshair along one edge of the subject. The two should be aligned at top and bottom. Adjust subject accordingly, move transit 90° and repeat.

eliminate this problem, we place rebar grade stakes on 8-ft. to 10-ft. centers across the entire floor area to guide our pour. We set up the level in the center of the floor and take a reading with the rod held on the perimeter of the leveled formwork. Say this reading is 4 ft. 8¼ in. The rod-holder slides the target to this reading. Then we drive all the rebar stakes, leaving them each a little bit high. Now the rod-holder holds the rod on one of the stakes, and we note how much more it needs to be driven to have the target line up with the level's horizontal crosshair when the rod is on the stake. This is a check-and-tap procedure. When I read 4 ft. 8¼ in. on the rod, I know the top of the stake and the forms are level with one another.

I like to spray-paint the tops of each stake as they are set to grade. That way we know when we're finished with all the stakes, they don't get kicked around as much, and the concrete guys can see them more easily during the pour. Once the stakes have done their job as reference points, they get driven below the surface of the slab before finish troweling.

Straight lines and plumb lines—Unlocking the vertical clamp on a transit allows you to take advantage of its ability to move up and down in a vertical plane. For instance, to align a row of trees, stakes, fence posts or columns with a transit, set up the instrument somewhere along that line. Sighting to another point known to be along the line will give you the required orientation. Now tighten the horizontal clamp screw to preserve the setting, and loosen the lever lock and the vertical clamp screw to allow the telescope to swing up and down in a vertical arc. Now you can align a stake, measure to the next one and align it (middle drawing, left). To extend the line in the opposite direction, turn the telescope 180°.

In this setting it's also possible to see along a plumb line, locating any number of points, whether on the ground or several floors up (bottom drawing, facing page). I think this ability to plumb by line-of-sight is one of the most useful functions of the transit. On several occasions I've used a transit to plumb formwork for concrete columns. They were too tall to be guessing with a 4-ft. level and there were too many angled braces projecting from the formwork to use a plumb bob. But because I could sight the top and bottom of the forms, I could adjust them into perfect alignment.

The transit is also useful when setting tall wood posts that may, and usually do, have a camber in them. This is especially true when it is inconvenient to drop a plumb bob off their tops, and a level won't help because the camber will throw you off. In this circumstance, begin by setting up the transit at least as far away as the object is tall. If the object is square, set up along one projected edge—on the building line for example—if the posts or columns fall on it. Any twist in the object from bottom to top can be detected at the same time you check plumb. Set the intersection of the crosshairs directly on the bottom edge, and raise the telescope. If the edge moves away from the vertical crosshair, you then know which way to move the object to bring it into plumb.

Next, move the instrument to a spot 90° from the first setup and repeat the operation from the new position. To avoid errors, make sure to lock the horizontal movement on the transit while checking for plumb.

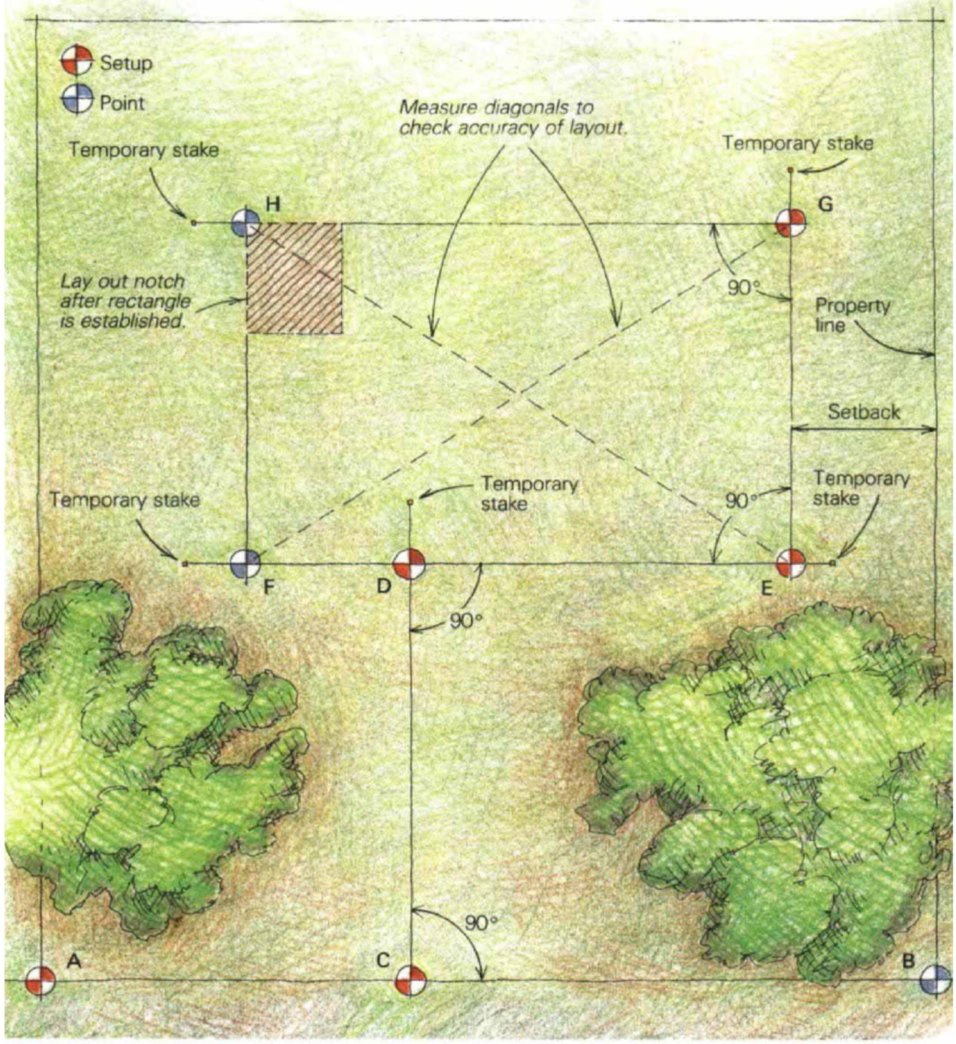
Layout with a level or transit—Laying out a building means locating the outside corners of its foundation, and marking them with stakes. Nails driven into the tops of the stakes register the precise intersection of the walls.

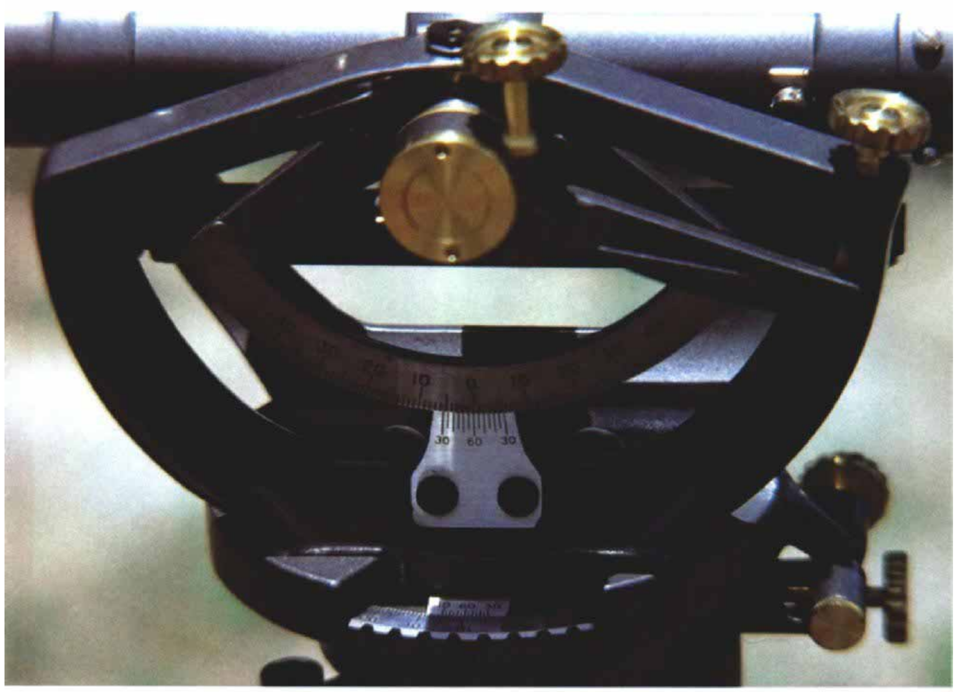
The starting point for any layout is the orientation of one side of the building's foundation (a building line) and one corner on that line. Site plans or plot plans usually have enough information about the dimensions of the lot to get you positioned on the site. Assuming that one boundary of the lot is parallel to a building line, I set up the transit over survey stake A at one corner of the lot, and focus the transit on the adjacent corner B (drawing, above right). Sometimes the view to the building is obscured along line AB by trees, bushes or even other structures so I have to find a point (C) on this line that gives me a clear shot of its position. I drive a stake at C, set up the transit, and I have my rod-holder place the rod atop corner stake B. I sight the vertical crosshair on one edge of the rod, and set the horizontal circle of the instrument on 0° (photo right). Rotating the instrument toward the building site, I lock it on 90°.

The rod-holder now moves to a point a few feet inside the building footprint, and adjusts the rod to the left or right until one edge lines up with the vertical crosshair. If the rod-holder is beyond the sound of my voice, I motion with my right or left arm, depending on the direction the rod needs to move. When it's on target, I

Building layout

Layouts typically begin by establishing a point along a property line (C) where the transit can be set up and a measurement taken to the building line. Once the building line and one corner are located, the major corners of the building are pinpointed with stakes and diagonals measured.

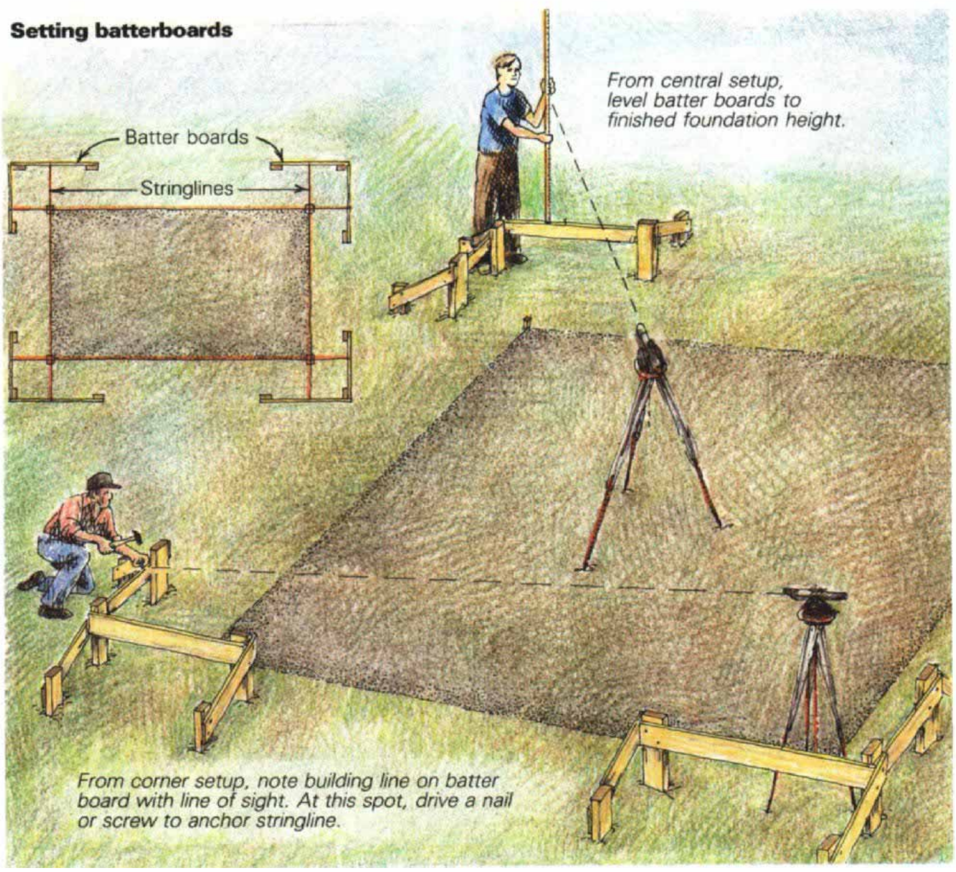




The two degree scales on a transit allow you to read angles in a horizontal or vertical arc. Here both are set at 0°. The instrument is now ready to be used as a level or to turn angles for layout.

Photo: Michelle Lord

Once the temporary stake is in the ground to establish alignment, a measurement can be made by pulling a steel tape between the new stake and a known corner such as this one.



raise both arms to signal "hold it." I then sight the bottom of the rod, where he drives a temporary stake and marks the vertical crosshair with a nail. If I'm using a level instead of a transit I can still do this operation, but my rod-holder has to use a string-line and a plumb bob to locate the placement of the nail. While it's possible to position a stake on the building line without the temporary stake, it usually ends up being easier to put in the temporary reference point—especially if you're using a level.

Now we measure the required distance along this perpendicular line, and with the tape pulled tight, drive stake D on the building line (drawing, previous page). With the transit set up over point D, I sight back to point C, set the horizontal circle at 0° and rotate the instrument 90° to the left. Now I'm sighting along the building line toward point E, which will be the first established corner. We place another temporary stake on the building line beyond point E, and measure the necessary setback from the property line to find point E. If the property line is difficult to locate, we can subtract the setback from line CB. If the lot is rectangular, the result will equal DE. Since I'm set up on the building line, I turn the transit 180° to set a temporary stake beyond corner F. Then I stretch a Stringline between corner E and the temporary stake, and measure the distance to F (photo above left).

Now that the first corner and first building line are established, I can set the rest of the corner stakes. The procedure is the same for the corners turned on the way to establishing corner E—setting up over a known point, sighting the building line, setting the degree scale on zero and turning the scope 90°. If the building footprint has a notch taken out of what is essentially a rectangular form (such as at corner H), lay out the rectangle first and check the diagonals to make sure they are the same length. Then you can place the stakes that delineate the notch.

The best rod-holder is one who understands how the level or transit works, so make sure he or she has a chance to look through the telescope, set a few grade stakes and turn a few angles. The rod-holder will also notice that the telescope can make the string appear to be the size of a rope, allowing you to sight either side of a Stringline. Consequently the rod-holder's plumb bob must really be still.

With the layout done, the batter boards *(FHB* #11, pp. 26-28) can be set up at the corners, at least 4 ft. outside the building lines. To get the batter boards level with the finished foundation, I set up the transit in the center of the building footprint and have the rod-holder adjust them to the required height (drawing, left). Then I set up the level or transit over each building line. I locate the lines by stretching strings between the corners. I can then extend the building line in either direction by line-of-sight onto the batter boards, where it is marked with a nail. With this arrangement you can stretch the stringlines again and have your location on the site, a level grade reference and the major building lines with corners where the stringlines cross. □

Stephen Suddarth is certified as a building contractor in the state of Florida.

Photo: Kamal Suddarth

Review of some level-transits

The instruments I've used include my own *David-White 8300 Universal Level-Transit,* shown in the drawing on p. 39. While it's a topnotch level-transit, it has been discontinued by Realist. A few are still available for $448 from Duder Stadt Supply, 2422 E. Southcross, San Antonio, Tex. 78223.

David White 8830 Meridian Level-Transit. This is one of the least expensive models of the instruments reviewed. It's a perfectly adequate beginner's instrument. $315.

David White LT8-300 Level-Transit. This is a new product with conventional features, but an optical plummet is available on the LT8-300P. It has a sleek modern appearance, with the same tolerances as the 8300. Solid and heavy, it turns very smoothly. Its adjustment knobs are simple and easy to find. The horizontal circle does move just a bit too easily however, which could cause errors in a layout. $539.

David White AL8-22 (8860) Automatic Level. This level spoiled me. It sets up quickly, it's accurate and stays accurate if the tripod is nudged. Looks sleek, has air-dampened gravity compensator to keep optics level. It does all its tasks well. $469.

Lietz Model 20 Transit-Level. This basic instrument has conventional features and is the least expensive of Lietz Transit-Levels. It seems well built with a handy magnetic locking device to secure the telescope in the horizontal position. $315.

While the latest levels and transits (such as this model LT8-300 from David White) have become more streamlined, their functions remain the same as their ancestors.

Sears Craftsman 9 46201 Contractors Transit-Level. This basic instrument has solid brass adjustment knobs and leveling screws, and tolerances similar to competitors. The vial is hung below the telescope, and I found it easier to read while leveling. I had no problems with this instrument in use. $289. *—S. S.*

Manufacturers

Listed below are the names and addresses of the principal American manufacturers and distributors of optical levels and transits, and laser levels.

A.G.L., 2615 W. Main St., Jacksonville, Ark. 72076 (laser levels).

Berger Instruments, 4 River St., Boston, Mass. 02126 (levels, transits).

Carl Heinrich Co., 711 Concord Ave., Cambridge, Mass. 02138 (distributors of Kern and Topcon levels and transits).

Laser Alignment, 2850 Thornhills SE, Grand Rapids, Mich. 49506 (laser levels).

Lietz/Sokkisha Co., 9111 Barton St., Box 2934, Overland Park, Kan. 66201 (levels, transits).

Realist Co., N 93 W 16288 Megal Drive, Menomonee Falls, Wis. 53051 (David White levels, transits and laser levels).

Sears, Roebuck and Co., Merchandise Group, Dept. 824FC, Sears Tower, Chicago, Ill. 60684 (levels, transits).

Spectra Physics, 5475 Kellenburger Rd., Dayton, Ohio 45424 (laser levels, electronic levels).

L. S. Starrett Co., 121 Crescent St., Athol, Mass. 01331 (levels, transits).

Wild Heerbrugg Instruments Inc., 465 Smith St., Farmingdale, N. Y. 11735 (levels, laser levels).

Carl Zeiss Inc., One Zeiss Dr., Thornwood, N. Y. 10594 (levels).

Laser levels

There are two types of laser levels: visible-beam and invisible-beam. Both use a rotating head for transmitting the beam in a level or plumb orientation.

Visible-laser levels emit a low-power, red beam of light that is about ⅜ in. in diameter, 300 ft. from the source. Realist's Blount Electronics Div. makes five models of visible-laser levels, all of which are self-leveling. The Milli-Beam (list price, $3,995) emits one milli-watt of power and covers more than a 600-ft. radius. The other four models emit two milli-watts of helium neon light. These very low levels of energy produce no detectable heat, but you are cautioned not to stare into the beam.

Realist's visible-laser levels operate on 12-volt DC, so they will work off a battery pack, a car battery or a 110 AC converter. Mounted on a tripod, the Milli-Beam rotates at variable speed (0 to 360 rpm), or mounts on its side for plumbing or 90° layouts.

Spectra-Physics offers two visible-light laser levels. Both mount on a tripod, hang on a wall or perch on trivet feet. Once adjusted to near-level, they level themselves automatically. Most contractors I've seen using the 910 (list, $5,995) or 942 (list, $5,195) Laser Level from Spectra-Physics simply hang them on a wall or column exactly at the desired height to do leveling operations. When lying on its side, the 910 Laser Level can lay out 90° angles by emitting a beam of red light straight out of the end of the rotating head, which is also emitting a beam simultaneously in a "plumb" vertical plane.

An invisible-laser level emits an infrared beam that can be detected by a small, hand-held sensor. When aligned with the beam, the sensor beeps and gives an LCD (liquid crystal display) readout. They are best used outside in bright light, when visible-laser beams are very hard to see.

Realist's invisible-laser level is the Electrobeam. It has essentially the same features as the Milli-Beam, including an automatic leveling system that is always in operation. This feature is typical of the higher-order optical transits used by engineers and surveyors, and is very handy when the building you are in is swaying or vibrating from construction operations.

Spectra-Physics' invisible-beam level is called the EL-1 Electronic Level ($2,995). Its range is 300 ft. The detector, called the Level-Eye, has an LCD as well as a fast beep for high, a slow beep for low, and a solid tone for on grade. The LCD flashes an arrow pointing down for high readings, and a line across its center for level. They also offer the model 1044-L Long Range EL-1. Range is 1,000 ft.

Has the laser technology in leveling instruments made the optical instruments obsolete? I don't think so. Optical instruments are here to stay. It appears that laser levels are quite valuable in specialized areas. They are fast and accurate, and on production-type commercial jobs the expense of a laser instrument is justified. Laser levels aren't designed to lay out buildings, so they lack the versatility of the optical instruments, and there aren't any laser transits.

Recent improvements to optical instruments, such as automatic-leveling, optical plummet (which replaces the plumb-bob operation) and tribrach mounting, all make optical instruments easier to set up. And easy setup has been a strong part of the sales pitch for laser levels. A person who has trouble leveling a conventional instrument should investigate those with automatic leveling.

In my discussions with Realist, a company that manufactures both optical and laser instruments, I was assured that optical levels will be far less expensive than laser levels for many years to come. Look out though. Wild/Magnavox now makes surveying transits that use data from 18 satellites. The readings appear on a terminal linked with a computer. The surveyor sets up in the field and never looks through a scope. *—S. S.*