The Lowdown on Levels

It may be the age of lasers and electronics, but a sturdy spirit level is still the job-site standard

by Scott Gibson

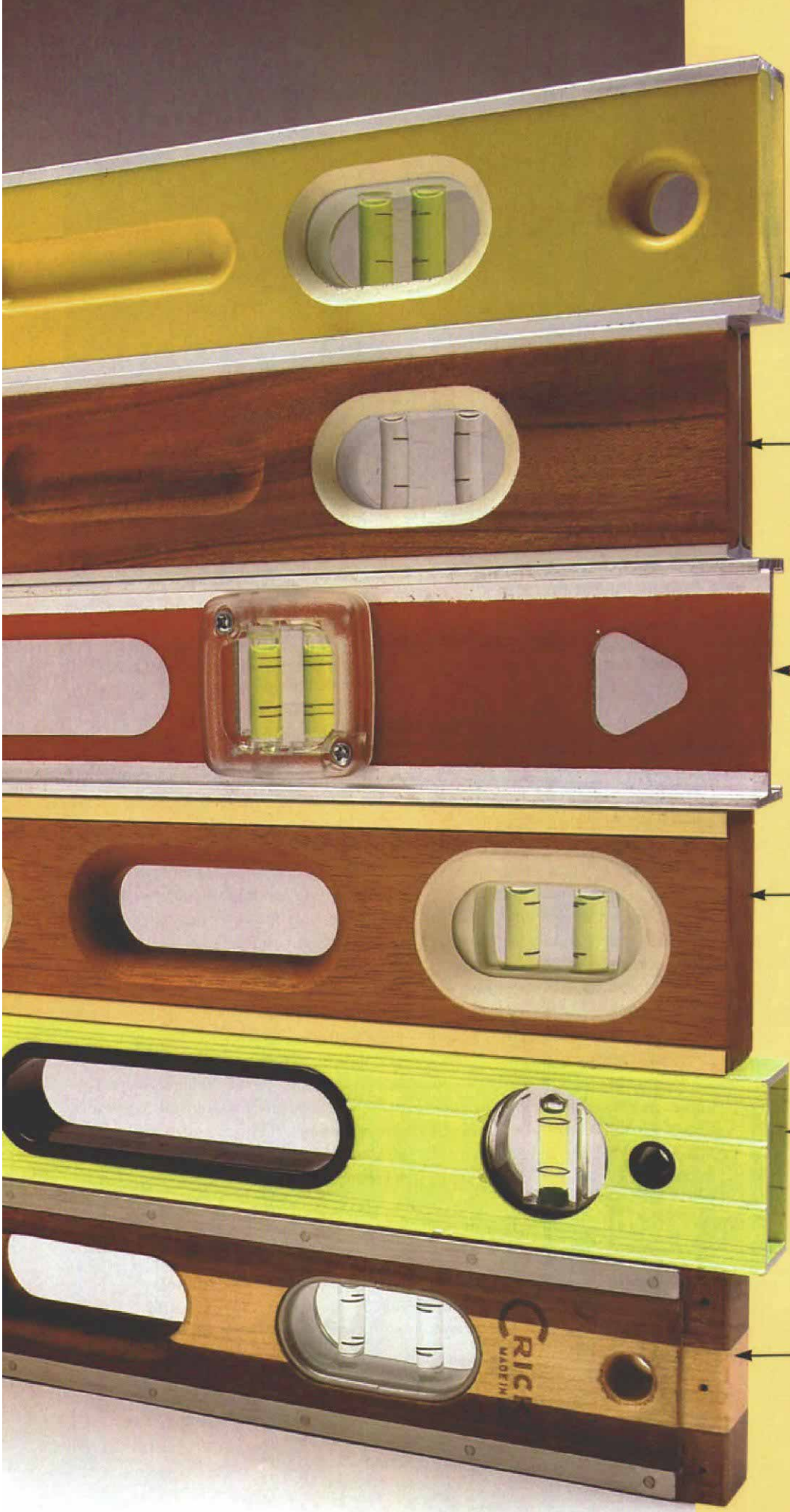
It has the last word on everything from framing walls to setting cabinets, but a carpenter's level still leads a dog's life. Knocked off staging, heaved in the back of pickups, dropped on concrete slabs, a level is expected to perform nothing short of a miracle: show even the slightest deviation from plumb or level. It's little wonder that millions of them are replaced every year.

Even if you're fussy about your tools, chances are good you'll eventually loan your level to someone who isn't. If it's been a while since you bought a new one, you may be surprised that you have so many kinds to choose from. Outwardly, the spirit level is fundamentally the same tool it was when your great grandfather framed his cow barn. All you have to do is center a bubble between two lines to check a surface either for level or for plumb. But in reality, spirit levels are more sophisticated these days: They are made of new materials, have new kinds of vials and are more accurate than they used to be.

For a better idea of what the market has to offer, I toured factories where levels are made, talked to people who use them and sampled dozens of levels from different manufacturers (sidebar p. 62). I wasn't attempting a brand-by-brand comparison. Instead, I wanted to learn more about how levels are made and what features are important. Electronic and laser stick levels were especially interesting. But after using two makes of electronic levels, plus a handful of laser stick levels, I couldn't help but think that they are special-occasion tools unlikely to dethrone the spirit level as the everyday king of the job site (sidebar p. 65).

Whether you use a 2-ft. level to set cabinets or a 78-in. level for plumbing door jambs, the mechanics of how a level works are just about the same. The field is dominated by two basic types: solid wood, usually mahogany with brass edging, and aluminum extrusions (photo above). The differences between the dozens of brands and styles are in the details: the type of extrusion or wood frame and the type of vial the manufacturer uses. There also are a number of spirit levels specially suited for certain trades—telescoping levels for framers or magnetic levels that stick to steel framing or pipes.

Vials are the heart of a level, and many of them these days are made of plastic—A vial isn't much more than a sealed container of liquid



THE STORY IS ON THE INSIDE

All of these spirit levels are designed to do the same job, but take a slice off the end and you'll find differences that affect durability and performance.

Plastic frames are waterproof and inert. Several manufacturers offer aluminum I-beam extrusions wrapped in plastic resin, a material more resistant to weather than wood.

Best of both worlds. It looks like a traditional mason's level, but this is an I-beam extrusion at heart. Mahogany-clad I-beams such as this one are less likely to warp than solid-wood levels and are warm to the touch, even on cold days.

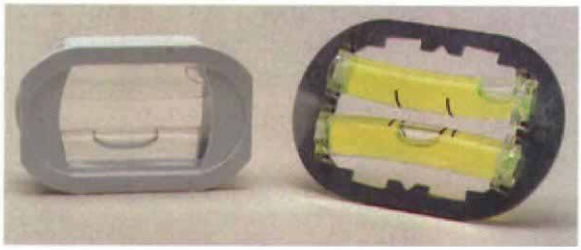
I-beams are basic. This aluminum I-beam level is typical of its class: light and strong but more flexible than other types. In many of them, vials are easily accessible for replacement.

Masons like mahogany. Honduras mahogany, stable and long wearing, is standard for solid-wood levels traditionally preferred by masons. Mahogany levels need regular treatment with linseed oil, but the wood does not bond well with mortar, a big advantage.

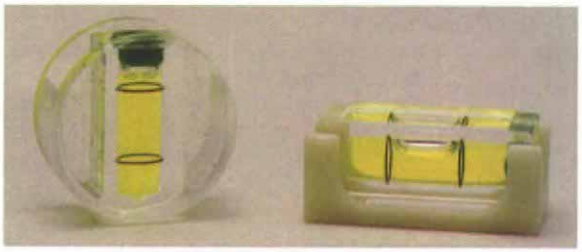
Box-beam levels are the rising stars. A number of U. S. companies now offer European-style levels made from aluminum box-beam extrusions, like this one. The design offers strength and rigidity at a relatively low weight.

Laminated-wood levels are designed to resist warping. Strips of mansonia and maple are glued together and then bound with stainless-steel edges in this Crick level. Pricey and beautiful, Crick (and the nearly identical Smith) levels have an intensely loyal following.

A LEVEL'S BRAIN IS ONLY A BUBBLE. A bubble trapped inside a plastic or glass vial is what tells you when a surface is plumb or level. Spirit levels get their name from the nonfreezing alcohol or mineral spirits in the vial.



Curved vials are traditional. Glass vials (left) were once the only choice, but manufacturers are increasingly turning to acrylic plastic versions (right).



Europe's contribution: tough and accurate. The solid-block acrylic vial, milled from a solid chunk of plastic, was popularized by German-based Stabila.

Barrel vials are curved only on the inside. Molded-barrel vials of acrylic plastic are cheap to make, and they can be read in any position. Manufacturers can substitute a single-barrel vial for two curved vials.

Both levels are at the same angle. And both are accurate. A quirk in the barrel vial (top) sends the bubble off to the end at a certain point. Bubble movement in the solid-block vial (bottom) is uniform.

with a bubble trapped inside. Simple? It only looks that way. Manufacturers have spent a lot of time and money developing new vials and finding better ways of mounting them in their levels. Curved-glass vials, which once were your only choice, are still a traditional fixture on mahogany mason's levels. But vials of acrylic plastic are a lot more common.

The direct descendant of the curved-glass vial is its curved-acrylic offspring (photo top left). Each vial station gets a pair of vials because each vial has a definite up and down. These vials are molded in sophisticated, fully automated presses in which molten acrylic is molded around curved cores. The hollow tubes are then filled with dyed mineral spirits or alcohol, capped and printed with reference lines. The process of making vials is far from simple, but the vials are fast and cheap to make.

Increasingly common are acrylic-barrel vials, which are cylindrical on the outside and barrel shaped on the inside (photo above center). Just like the curved vials, these are made by injecting molten acrylic around a core inside a mold. The core is barrel shaped along its length—fatter in the middle than at either end. The result is a curved hollow inside a straight tube. Unlike a curved vial, which must be set into a level in only one position, these vials can be read in any direction. Manufacturers like them because a single-barrel vial can replace two curved vials.

Barrel vials, which are standard on extruded aluminum I-beam levels, have a quirk. The molding process creates a straight section at either end of the cylinder. As a result, the bubble has a tendency to zip off to one side once it reaches a certain point inside the vial, giving the vial a more limited working range than a curved vial (photo right). And because of the molding process, barrel vials are more susceptible to slight manufacturing variances than other types.

If molded vials are the Chevrolets of the business, the solid-block acrylic vial (photo bottom left) is the Cadillac. Milled from chunks of plastic, solid-block vials are close to bulletproof, and their rectangular outside shape lends itself to a secure connection with the level's frame. The curve on the inside of a solid-block vial is uniform, which means the bubble's movement is uniform across the full working range of the level. Reference lines are little pieces of wire set into tiny grooves inside the vial, so they are sharp and precise and less prone to distortion than lines stamped outside a vial. Solid-block vials are the most expensive of the three. They're standard on European-style aluminum box-beam levels and on some levels made in the United States.

Level manufacturers

The following list of level manufacturers is by no means complete, but it includes companies whose products are mentioned in this article. Where available, Websites are also noted.

Crick Level Co.
(800) 593-8540

Empire Level Mfg. Corp.
(800) 636-8425
www.empirelevel.com

Johnson Level & Tool
(414) 242-1161
www.johnsonlevel.com

Levelution
(888) 475-3835

L. S. Starrett Co.
(978) 249-5330
www.qualitymag.com/Starrett

Macklanburg-Duncan
(800) 654-0007

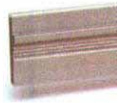
Plumb-It Inc.
(800) 759-9925
www.plumb-it.com

Smith Level Co.
(800) 444-0929

Stabila
(800) 869-7460

Stanley Tools
(800) 262-2161
www.stanleyworks.com

Zircon
(800) 245-9265
www.zircon.com



Just how accurate do you need a level to be?—Fresh from the factory, and assuming it was inspected properly, any professional-grade level should be accurate when you buy it—to a point. Each maker sets its own standard for accuracy.

How do you measure accuracy? You put a level on a reference surface, such as a big slab of machined granite, and then measure the amount you have to raise one end of the level to center the bubble. A 2-ft. level that has to be shimmed at one end by 0.024 in. to center the bubble would just meet an accuracy spec of 0.001 in. per in. (or 1mm/m). This number can also be described as an angle. The 0.001-in. angle is 0.059° .Some manufacturers stamp the accuracy right on their levels. Most don't.

I found that many manufacturers build their best levels to this 0.001-in. standard, which means no level can leave the factory unless it's at least as good as that. The next step up is a level good to 0.0005 in. Does this, you'd be wise to ask, have any practical meaning? Look at the math and decide for yourself. A 4-ft. level built to the 0.001-in. tolerance could be out by as much as 3/64 in. and still have the bubble dead center between the lines. On an 8-ft. wall, that grows to 3/32 in. If you used the level to walk around a 12-ft. by 14-ft. room to set chair rail, you could be off by as much as 5/8 in. when you got back to your starting point (unless you flipped the level end for end each time, which would offset any error). If you use a level built to the 0.0005-in. standard, cut all those errors in half.

A couple of caveats: These numbers represent the most a level could be out and still meet manufacturing specs. They assume you take your time sighting the bubble, and that you remember a level usually has one reference surface, not two. That means that in checking for level, most tools must have the vial up to get the accuracy its manufacturer promises.

More accurate doesn't always mean better. Starrett makes a painfully accurate machinist's level that other level manufacturers use to set up their own test benches. But the vial has such a slight arc and is so sensitive to movement that it takes many minutes for the bubble to come to rest. Although you could set a kitchen cabinet to within a gnat's eyelash with such a tool, you'd need three days to do it, and you'd have to wonder whether anyone would ever notice.

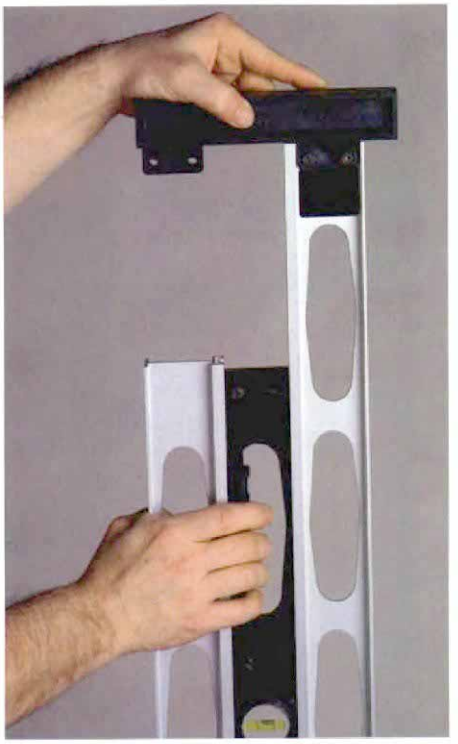
Solid-wood levels are the old standard—The all-mahogany level (photo p. 61) has long been a standard mason's tool because it resists the grip of wet mortar, which aluminum doesn't, and because its smooth profile doesn't give mortar and other debris much of a place to hide. These levels usually are equipped with pairs of curved-glass or acrylic vials at each vial station and glass vial protectors (tiny windows) that resist abrasion. Oiled mahogany has a heft and visual appeal that a plain aluminum extrusion can't hope to match, and wood is warm to the touch.

Fans of mahogany levels are immovable. Stanley Tools, for example, uses some 500,000 bd. ft. of clear, straight-grained mahogany a year to make their mahogany levels. The 3-in. thick material is stacked nearly to the rafters in the back of Stanley's Pittsfield, Vermont, factory. Level blanks are quartersawn from these mouth-watering planks so that they are more stable than plain flat-sawn lumber. Stanley uses sophisticated, computer-driven equipment to mill the blanks and is exacting in its approach to fitting vials. Other manufacturers no doubt can make similar claims.

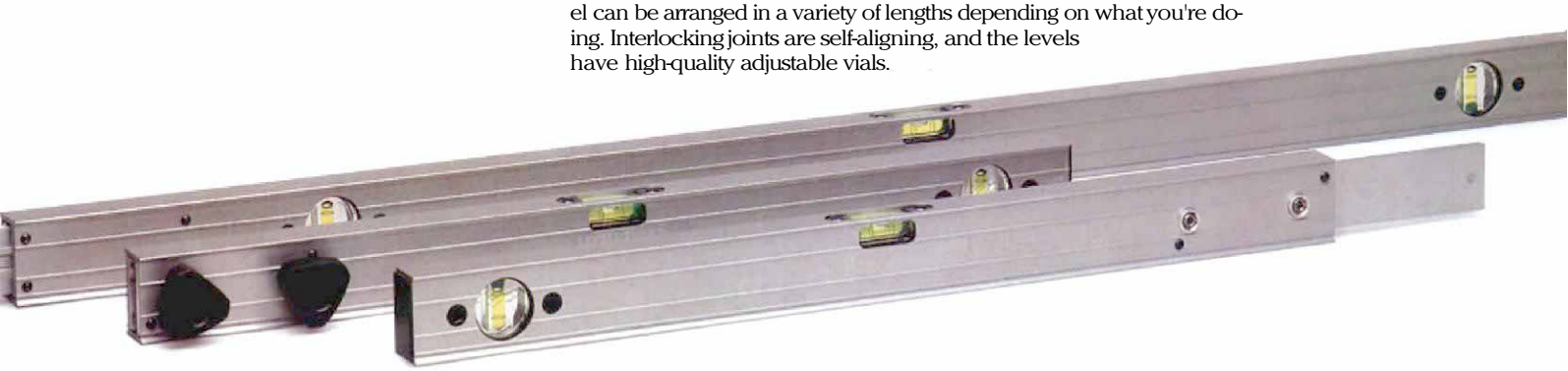
In the end, solid-mahogany levels are sticks of wood, and wood can be unpredictable. Even with the best mahogany and careful manufacturing, solid-wood levels are more susceptible to distortion than metal, especially in regions with wide

LEVELS THAT GROW TO THE JOB. Two levels—the Plumb-it and the Levelution System—can be adjusted in length to match the job at hand.

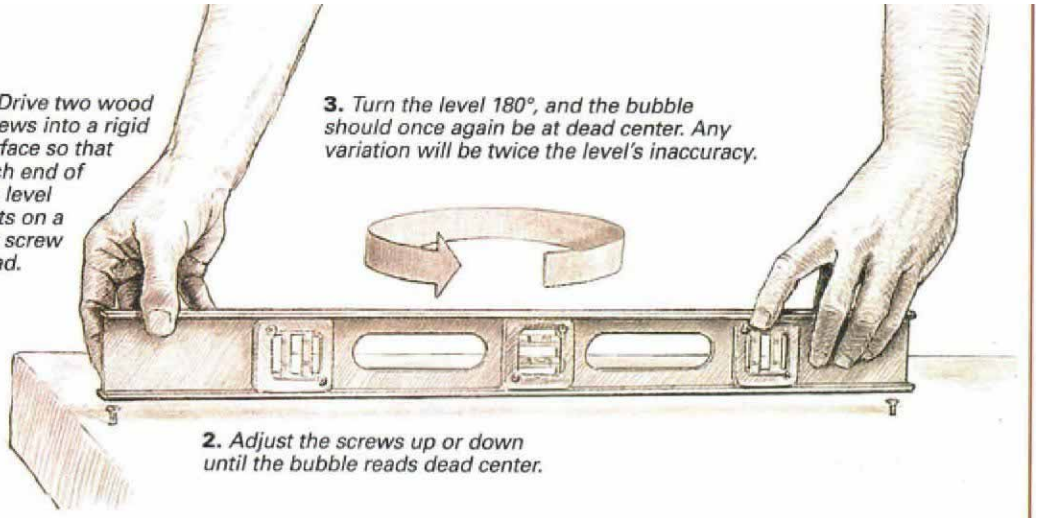
A level for tall walls. The Plumb-It telescoping level is unique. This model stretches from about 4 ft. to more than 10 ft. as one or both of its outboard arms are adjusted. Vials are high-quality solid-block acrylic.



Components make levels of many lengths. A Levelution System level can be arranged in a variety of lengths depending on what you're doing. Interlocking joints are self-aligning, and the levels have high-quality adjustable vials.



What to do when your level suddenly goes bad



Checking your level: It takes no time at all to check the accuracy of your spirit level—a good idea if it's been abused and an even better idea when buying a new level. One method suggested by Bill Crick of the Crick Level Company some years back is explained in the drawings at right. A shortcut is to skip the wood screws and place the level on a flat surface that's reasonably level (it doesn't have to be perfect). If the bubble is in exactly the same relative position after the level is rotated, the level is accurate.

To check the plumb vial, hold the level upright against a straight vertical surface, and note the position of the bubble in the vial. Rotate the level edge for edge (not end for end) and check it again. The bubble should be in the same spot.

Adjusting or repairing a level: If you discover your level is out of true, what options do you have (other than throwing it away)? Some levels have to go back to the factory, where they can be repaired and recalibrated. Others will just have to be replaced—there's no way to separate some solid-block vial systems from their frames.

But there are levels you can fix or adjust yourself. The two photos below show variations on this theme. Vials on aluminum I-beam extrusions are usually accessible. Vials in some mahogany levels are glazed in place and hard to get at. Others, like the Stanley (photo below left), use rubber gaskets that can be pulled off to expose the vials.

Replacement plastic vials are inexpensive, and they should be available from the manufacturer.

Many carpenters and manufacturers don't like adjustable vials, arguing they might drift out of true when you don't expect it. But there also are good arguments in their favor. The Starrett (photo below right) and the Levelution levels are among those that can be quickly brought back to true.- *S. G.*

We're going in. Some levels permit quick replacement of broken vials (left). To change vials in this Stanley mason's level, pry up the rubber seal, pop out the broken vial, and snap in a new one. New vials are cheap.

When the level is off, just find a screwdriver. This Starrett aluminum level can be recalibrated with nothing more than a Phillips screwdriver. Turning a recessed screw reorients the vial.

temperature and humidity swings. Mahogany levels need regular slatherings of linseed oil.

Another potential worry is rain-forest politics. There may come a day when mahogany is too hard to get. Stanley has been trying other woods. Gary Bannister, the plant manager for Stanley's Pittsfield operation, even has an experimental level made of padauk in his office. It's luscious and dark grained, as opulent as a sultan's humidor. Also, too heavy to lug around all day.

Laminated-wood levels have ardent fans— Another solid-wood option is a laminated level from the Smith Level Company or from Crick (sidebar p. 62). They look virtually identical, maybe because Smith and Crick, who founded their respective companies, apparently knew each other. Both of these beautiful tools are made from strips of mansonia, also called African walnut, and maple. Smith uses a tongue-and-groove joint in its laminations; Crick no longer does.

Both Smith and Crick levels are reinforced with stainlesssteel edging and come with curved-glass vials. They're intended for masons, but carpenters like them, too. Massachusetts builder Bob Weatherall thinks so much of his Crick that he ordered 12-in. models for the ushers at his wedding a few years back. Smiths and Cricks are expensive (more than $80 for a standard 4-footer), and plan on waiting a while if you want one. But the levels are guaranteed accurate to within 0.0015 in. regardless of length.

If it's got to be mahogany, consider an I-beam extrusion clad in wood–More durable than a solid-mahogany level—and a lot less likely to change shape over time—is an I-beam level with mahogany infill. These levels are made by a number of companies and have all the eye appeal of their solid-wood cousins without the built-in potential for long-term warping problems. They are basically heavy-gauge aluminum extrusions into which thin pieces of mahogany have been glued. The wood stiffens the extrusion, and it makes the level look nicer and feel warmer to

Photos this, facing page: Scott Gibson. Drawing: Dan Thornton.

the touch in cold weather. Although the Starrett uses a solid-block acrylic vial, most brands I saw come with curved glass or acrylic vials.

If you're not hung up on mahogany, you can get an I-beam level with a plastic infill, which is impervious to all weather conditions known to man. Macklanburg-Duncan's American 9000 brand is one such level The Empire Magnum level is another (photo p. 61).

I-beam levels are the plain vanilla offering: nothing trendy but serviceable—Take away the plastic or mahogany, and what you have is an I-beam extrusion: light, fairly strong and inexpensive. The I-beam level has, for many manufacturers, replaced die-cast aluminum.

I-beam extrusions are available in many styles. Some have a V-groove along one edge to fit over a pipe. Others have magnetic strips along one edge to hold the level firmly against metal framing. Some have slots punched in the top edge to make the vials visible from above. Vials either snap directly into the extrusion or fit in a plastic holder screwed to the extrusion. Extruded I-beam levels often have vials that can be replaced or adjusted in the field (sidebar facing page).

If you want an idea of the difference between a top-quality I-beam level and what the manufacturers call DIV (do-it-yourself) models, just give them a twist. Lower-grade extrusions are thinner and feel flimsy. But even top-grade I-beam levels are a good deal more flexible than other styles.

Stabila gave European level design a boost in the United States—Gary Katz, a builder in southern California, became an overnight convert to Stabila levels after he had to rip out a houseful of door jambs that he'd set with a level that was slightly off. The out-of-plumb jambs proved to be an expensive mistake, and Gary felt a little foolish when the drywallers came in and found the problem. His brother had been raving about Stabila levels, so he bought one.

Chalk up another one for the German company whose bright-yellow levels were first introduced in the United States in the mid-1980s. Stabila levels are box-beam extrusions, made in the same process as the I-beam but with a stiffer, stronger cross section (photo p. 61). Stabila's success has encouraged other manufacturers to offer box-beam levels, a style long popular in Europe.

Box beams are the strongest of the aluminum extrusions without being much heavier than an I-beam. Another plus: the durable solid-block vials that box-beam levels get. On the downside, vials in most box beams are fixed, so if the level goes out of alignment, you'll have to send it back for recalibration or buy a new one. Box-beam levels seem to be more expensive than other styles.

There are two common complaints about box-beam extrusions. One is that the center vial is recessed into the top edge of the level in lengths under 6 ft., making it hard to draw an unbroken level line across a wall (Levelution's model is an exception). Another is that tapered end caps make it tough to draw a straight line into a comer. But among the levels I looked at, all but two of those claiming the highest degree of accuracy were box-beam extrusions with solid-block vials (Crick and Smith were the exceptions).

Levels for tall places—Many manufacturers make longer levels for plumbing door jambs or walls, but two levels deserve special note (top photos, p. 63). One is the Plumb-It, made by Paul Semler, a framer turned manufacturer. Semler is the only level maker in the United States I could find who makes his own solid-block acrylic vials. The vials are securely fixed in an aluminum extrusion flanked by two movable arms that allow the height of the level to be adjusted.

The other adjustable level is the Levelution System (bottom photo, p. 63). The kit consists of box-beam components that lock together to make levels of different lengths. (For a review of the Levelution System, see p. 118.)

Die-cast aluminum levels were once the mark of quality—There are still people who swear by die-cast levels. But these tools probably are on the decline. Robert Owens, a product-engineering manager for Stanley, says the die-cast level was big before aluminum extrusions. The casting process, however, tends to make the metal porous, and thus harder to mill smoothly. And despite appearances (these things are really heavy), cast aluminum is not as strong as extruded aluminum, says Owens. □

Scott Gibson is senior editor at Fine Homebuilding.
Photos by Scott Phillips, except where noted

Electronic levels are a new twist on an old idea

Electronic levels look basically like their conventional counterparts. But spirit vials have been replaced by (or are supplemented by) LED screens that indicate with chirps, beeps, waving lines or numbers how near or far you may be from level or plumb. Patents on the technology behind the first electronic level, the SmartLevel, have sharply limited competition. Macklanburg-Duncan bought SmartLevel, then redesigned it and renamed it the SmartTool. The only competitor I could find is Zircon, which produces both electronic and laser levels (photos right).

Although similar in some ways, the SmartTool and Zircon's VideoLevel have parted company at an important fork in the road. Zircon is designed as an outright replacement for a spirit level—it has no spirit vials at all. SmartTool combines electronic components with solid-block acrylic vials, so you can use whichever device makes the most sense.

These levels can memorize angles for duplication elsewhere, and they give precise readouts for ⅛-in. and ¼-in. slopes, useful for setting drain line. SmartTool also offers slope readings in any one of three ways: in degrees, as a percentage or in inches per foot. Both brands are a snap to recalibrate. Zircon promises accuracy of plus or minus 1/64 in. over 4 ft. in its top-of-the-line VideoLevel 6.2-almost three times as accurate as a standard spirit level. SmartTool is said to be accurate to within roughly 0.002 in. per in.

Are these tools replacements for spirit levels? Not for me. The digital displays were not as familiar or as friendly as a plain old bubble in a vial. I found it more difficult to gauge how close to level or plumb the tool was getting, especially with the extremely sensitive Zircon. These levels would be attractive to me only if I needed their special features routinely.

Another whole category is the laser stick level, made by many Companies. They tend to be expensive, but extremely well suited to jobs where you want to shoot a number of reference points around a room that are all in a single plane (as you set chair rail, for instance). They are not an outright replacement for spirit levels.—*S. G.*