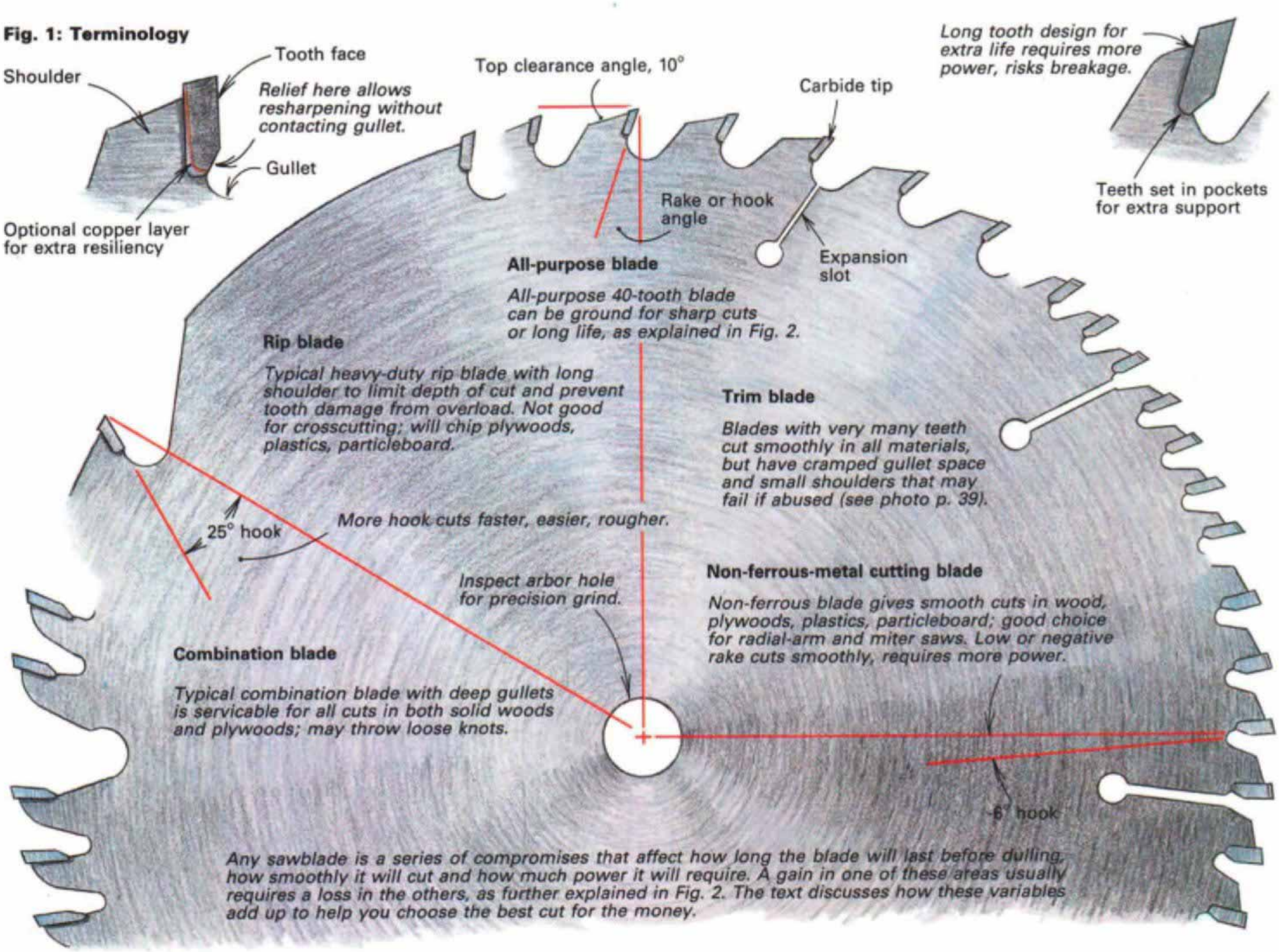
Carbide Sawblades

Compromises in quality make for affordable cuts

by Jim Cummins



A top-of-the-line carbide tablesaw blade costs more than some motorized 10-in. tablesaws. Does it make sense for a woodworker to shell out $100-plus for such a blade? There's no single answer, but after researching this article, I formulated a two-part rule of thumb: First, don't spend more than 15% of the cost of your tablesaw on any one blade; second, figure on spending from 25% to 50% of the saw's cost on three or four special-purpose blades that will let you cut just about anything. While this may sound arbitrary, it's based on careful observations.

No sawblade can be better than the tablesaw powering it. In fact, I spent about $900 on sawblades for my Sears saw in the first five years I ran my shop, ignorantly buying toothier blades each time in hopes of finding one that would cut both smoothly and at an economical rate. It wasn't until I bought a Rockwell/Delta Contractors Saw with about 50% more horsepower that I found out I had some real winners. Four of these are in constant use today, while the rest of my investment mostly hangs on the wall.

I'll tell you what my old favorites are, but I'm convinced that the most significant part of my list is the *type* of blade, not the manufacturer: a 10-tooth ripping blade (Winchester), which can slog through full-depth cuts on anything I've ever fed it; a 40-tooth combination blade (Freud) that's on the saw 95% of the time; an 80-tooth, thin-kerf plywood blade (Freud); and a 120-tooth no-set steel blade (Simonds), which I use for cutting aluminum picture-frame molding, but which can give me a glassy surface on wood on the few days a year I want it. At one time, all my blades were steel. I switched to carbide because my steel blades dulled too quickly, especially in abrasive, man-made materials. One saw-blade manufacturer I talked with mentioned an informal test his company had done comparing two types of carbide blades with a steel blade. One carbide blade cut 12,000 linear ft. of particle-board; the other cut 9,000 ft.; the steel blade was hopelessly dull after 300 ft.

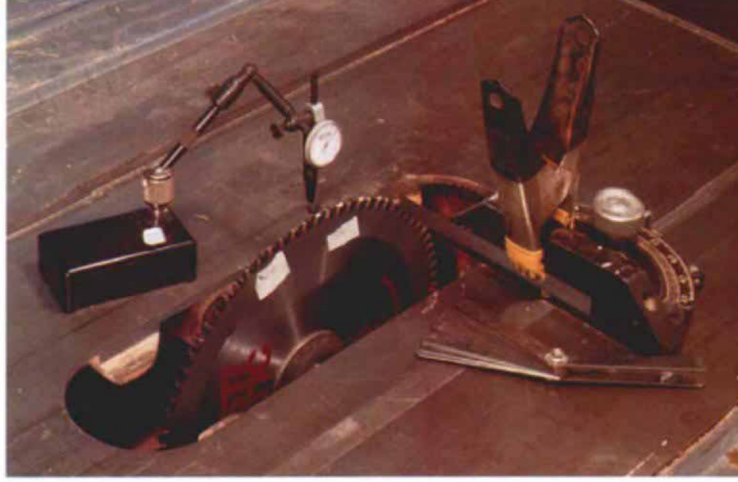
My saw is now about 10 years old, and while it's in pretty good tune and a darn nice machine for the money, it's incapable of showing up noticeable differences in blades that cost more than about $55. But when I tried the same expensive sawblades on a new, fine-tuned, General tablesaw, their special qualities became apparent. The owner of the saw, Jim Van Etten of Perkasie, N.J., had recently spent three hours getting the blade perfectly parallel with the miter slots, aligning his Biesemeyer fence and adjusting his shopmade sliding tables. This attention is critical for smooth, splinter-free cuts. One easy day-to-day test for proper fence alignment is that both sides of the cut should show an X-pattern resulting from the front teeth cutting down and the back teeth cutting up. For some applications, the back of the fence can be canted a hair away from the blade. This will give a smoother cut on the fence side of the blade, but on the offcut, the teeth at the back of the blade will cause a rough cut and surface tearout.

For this article, I interviewed major sawblade manufacturers, as well as some small saw shops. I called woodworkers around the country for their opinions. I bought, and borrowed, about four dozen blades, tried them in my shop and persuaded other wood-workers to try them in theirs. Taking a look at this assortment is by no means a "test." That would require subjecting perhaps three dozen blades of each design from each manufacturer to test cuts until they were dull. Without such rigor, results are bound to be subjective, although some clear patterns did emerge: Saw-blades do work best cutting the materials the manufacturers say they should cut and, yes, you get what you pay for. When I counted last, I owned 28 sawblades; the ones that I prefer to use are the most expensive in each category. This doesn't mean, however, that you have to pay big bucks for good cuts.

Grades and tolerances -Most manufacturers make several grades of blades, aimed at three broad markets. The top line is for industrial use. The middle line is for contractors. The bottom line is for "consumers."

Industry needs sawblades so uniform they can be ganged up 10 or more at a time on an arbor, then run at high horsepower and feed rates. Ten-inch industrial blades sell in the range from $75 to $200, depending on the number of teeth. Even so, a large part of the blade's cost is the plate—the alloy-steel disc the teeth are brazed to. Both the initial cost of the plate and the cost of the manufacturing steps to bring it to close tolerances can make an expensive blade even more costly.

Contractors don't need industrial-quality blades and are more likely to be concerned with the most cut for the dollar. By relax-ing tolerances a little and automating, manufacturers can sell very good blades between $35 and $60. Special promotions can yield incredible values—Freud's new version of my old combination blade, for example, costs less than half, from today's discounters, of what I paid retail. Similar values from U.S. Saw, DML, SystiMa-tic, Delta, Amana, FS Tool, Forrest and all the others competing for your dollar make carbide blades real bargains.



Two setups for checking blade/arbor runout. If you don't have a dial indicator, you can make do with an engineers' rule clamped to the miter gauge and an automotive feeler gauge to check the gaps. The masking tape on this blade indicates high spots—initial runout was 0.007 in.—yet by reorienting the blade on the arbor, it was made to run true.

Industry thinks "consumers" just want to get the job done as cheaply as possible. Tolerances are so loose in this part of the market that it's safe to generalize: Good blades don't come in blister packs; the flashier the packaging, the cheaper the blade.

The technology to make the best sawblade in the world is available to anyone who wants to use it. The few proprietary patents and new tooth designs don't amount to all that much. In fact, any carbide sawblade you pick up is likely to be worth the money, provided you buy it on sale. There are many ways to get sawblades into an attractive price range for contractors and homeowners. It's a benefit, when making up your mind to buy, to be able to discern where the cost cutting was done. First, let's consider the saw plate.

The plate —The plate should be alloy steel that's tempered to an appropriate hardness. Standards range anywhere from 30Rc (Rockwell C scale) to 46Rc or even 48Rc. Most plates on industrial blades range from 38Rc to 44Rc. The higher the plate hardness, the more the blade can be deflected and twisted without perma-nent deformation. Some manufacturers talk about plate hardness in their ads, and you can always ask the ones who don't. For the average woodworker feeding the saw by hand, plate hardness is not as important as it is in industry, where feed rates can approach 300 ft. per minute.

What is important is that the plate is the reference for all sharpening. The arbor hole in the plate should be as snug as pos-sible on the arbor. It is the reference for the concentricity of the teeth; the plate surface just below the teeth is the reference for top, face and side grinding. Two ways of checking plate flatness, or runout, are shown in the photo above. Holding a hacklit straightedge against the plate will also show runout. A plate that is not flat will be forced flat as each tooth is sharpened, then will spring back, leaving the teeth out of line. A blade that is not con-centric because of a loose-fitting arbor hole, or that has teeth out of line, will not only be less efficient and less smooth cutting, but will require more frequent sharpenings, at $10 to $20 a shot.

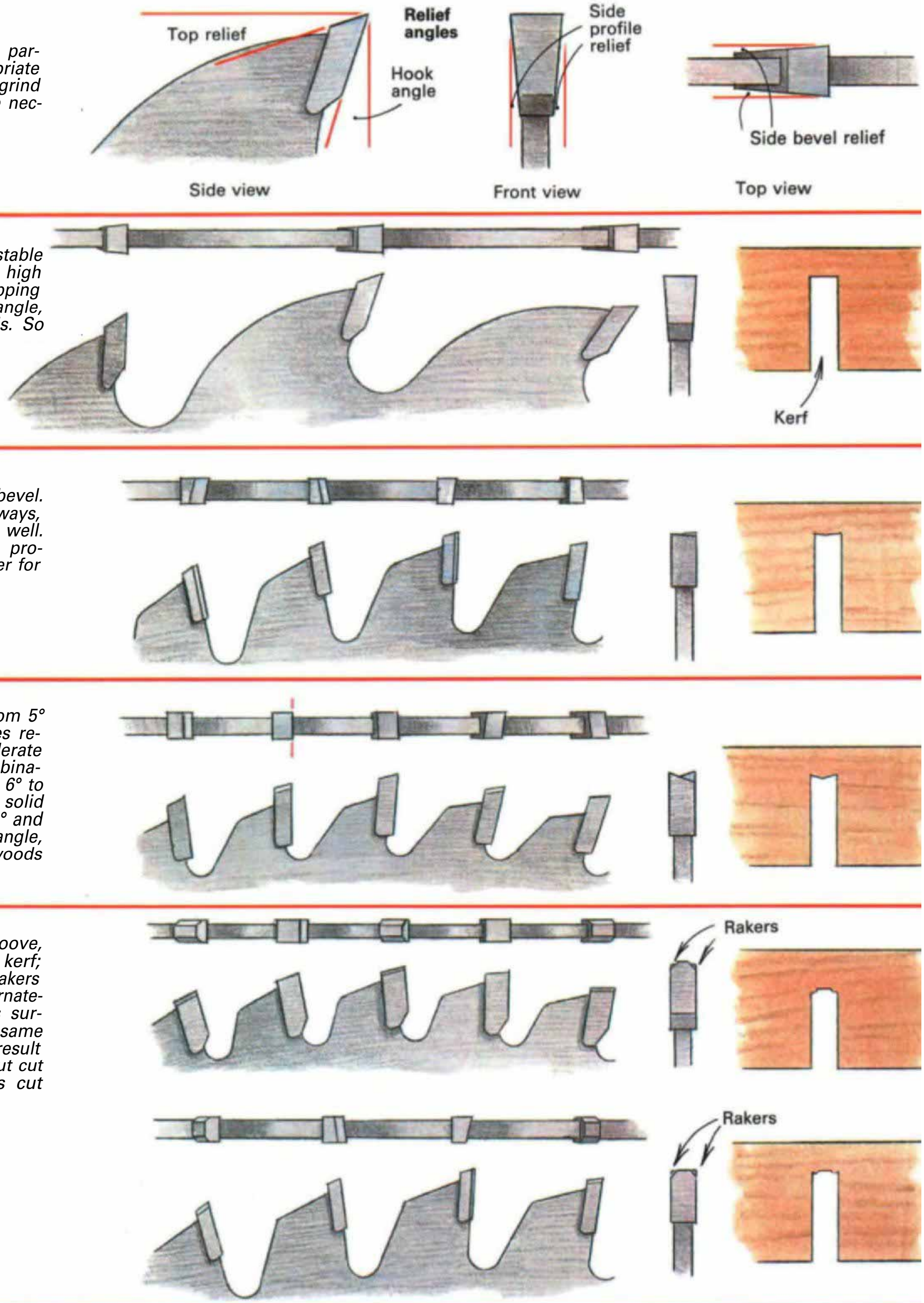
Cheap plates are merely punched out—as if using a cookie cut-ter—then polished to look good in the store. The dividing line seems to be about $25, discount price. Such a blade might be an excellent value if you plan to rough-cut cheap stock and discard the blade after a sharpening or two.

Better plates are flattened by sanding or grinding. A sanded plate will show grind marks that spiral out noticeably toward the rim; ground plates, which can be made more precisely, will show marks that are concentric. The finer the grind marks, generally, the more careful the manufacturer was. A plate can lose its flatness through abuse. Sticking a screwdriver in an expansion slot to loosen the arbor nut is not wise—as little as 0.001-in. abrupt runout makes for a noticeably scratchy cut. Heat buildup from hard running or forcing an overdull blade can also distort the plate.

Manufacturers go to great lengths to make sawblades look good, but one thing that hasn't occurred to them yet is that you can look into the arbor hole and tell a lot about how carefully a blade was made. Cheap arbor holes are simply punched to size, and this is obvious to the eye. The edges of the hole will be bent in, and there will be a fracture line within the hole showing where the center popped loose. Better arbor holes are at first cut or punched to a rough diameter, then brought to true round by reaming or grinding. Reaming is fast and leaves a smooth surface with minor, intermittent scoring and chatter marks. Grinding is better, but bad grinding is done fast, leaving slag and rough score marks. Manufacturers who skimp on arbor-hole machining tend to make the hole oversize, on the theory that if a blade fits loosely, it's better than if it doesn't fit at all. But if a blade fits loosely, it's only by luck that you'll ever get it to run true.

The other quality affecting the plate is its tensioning. Tension-

Fig. **2: Grinds**



Blades can be designed to work best in particular materials by choosing the appropriate combination of hook angle, grind type, grind angles and number of teeth. Some of the necessary compromises are noted below.

Flat or rip grind chops into endgrain-is stable in cut, long lasting, but takes power. With high hook angle, this profile is good for ripping solid wood. With low or negative hook angle, this profile is good for non-ferrous metals. So called 'glue line' blades have reduced side profile relief and cut slower.

Alternate face bevel imparts slight top bevel. Face bevels are most often, but not always, seen on teeth that have top bevels as well. Face bevels tend to clear sawdust well, producing longer life and requiring less power for fast feed in all materials.

Alternate top bevels slice, and may be from 5° to 40°. Mild bevels with high hook angles reduce power demands for ripping; moderate bevels of 10° to 20°, usually seen in combination with moderate hook angles of from 6° to 15°, cut clean for all-purpose work in solid woods, most plywoods; high bevels, 25° and up, usually with low or negative hook angle, minimize surface tearout in delicate plywoods and melamine.

Triple-chip tooth gouges out initial groove, limiting surface tearout to center of kerf; rakers then clean-cut edges of kerf. Rakers may be flat grind for long life (top), alternate-top-bevel or alternate-face-bevel for less surface tearout (bottom). Hook angles have same effects noted above: High hook angles result in longer life with less power required, but cut rougher; low or negative hook angles cut smoother, require higher feed pressure.

ing is pre-distorting the saw plate by means of hammering or roller pressure. This leaves stresses in the steel that tend to push the blade's rim out when the blade is at rest. When the blade is running, centrifugal force at the rim balances the tensioning and lets the plate run true. Tensioning also allows for some rim expansion from heat buildup. To a major extent, the blade's expansion slots leave room for this, and I believe that tensioning of a 10-in, blade in average use is less important than its flatness. Runout, or blade wobble, should be no more than 0.004 in., and a gradual runout affecting many teeth is better than an abrupt one.

Plates can be made in various thicknesses. Some Japanese plates are so thin that they cut kerfs barely more than 1⁄16 in. wide, while some rip blades clear a kerf of almost 3⁄16 in., and a number of blades have thin-rim designs that feature a heavy plate in the center with a thinner edge. Standard plate thickness is about 0.085 in., which seems good for most work. My favorite rip blade's plate is 0.095 in. thick. I like the heavy plate on this blade for several reasons: Its mass keeps it turning when a thin plate might bind and helps damp out shock from hitting knots or contrary grain. And it's also almost deflection-free.

A good case can be made for thin-kerf blades, provided they are not misused. On tablesaws that bog down frequently, a blade with a narrower kerf has the advantage of needing less power because it is removing less wood. The main problem with thin-kerf blades is vibration in the cut, causing deep gouging that has to be planed or sanded away. It is a good idea not to force thin-kerf blades so that they slow down from normal speed range the blade's natural vibration frequency will become excited and amplified by vibrations generated in cutting, causing the blade to flutter. Also, don't feed too slowly, as heat buildup may distort the plate. I have not found that stiffeners or dampeners are necessary to get good cuts on my saw, but on a more powerful saw allowing faster feed rates, they may prove beneficial. It is a good idea to save thin-kerf blades for cutting top-grade stock that's not likely to warp or twist. As one woodworker I talked with put it: "When you're cutting a $200 claro walnut board or a $100 sheet of plywood, a thin-kerf blade can mean the difference between a usable offcut and a piece of scrap." Smaller diameters of the thin-kerf family make admirable blades for hand-held circular saws, because their free-cutting action greatly reduces fatigue.

Here's a tip from the experts: After you tighten the arbor nut, give the saw a short power bump, then watch for runout as the blade winds down. If there's any runout visible, change the blade's orientation on the arbor and try again until it runs true. If using stabilizers or a dampener, rotate these to various orientations as well. While checking one sawblade with a dial indicator, I was able to reduce a runout of 0.007 in. to nothing—a freak occurrence where my arbor and plate runout exactly cancelled each other.

The carbide—Carbide is composed of fine grains of extremely hard tungsten-carbon particles cemented together with cobalt as a binder in a process called sintering, which involves pressing powders together, while applying heat below melting temperature, to produce a coherent mass. Carbide is usually rated on a hardness scale from Cl (soft and tough, with up to 8% cobalt) to C4 (hard and brittle, with as little as 2% cobalt). I would not make a big deal about which carbide grade the manufacturer uses, because Cl carbide is about 89Rc, and C4 is about 94Rc (diamond is l00Rc). Also, the "C" rating does not define the material-carbide grains may be coarse, fine or mixed; binder alloys vary; homogeneity within each tooth can vary. Cheap carbide may be so full of voids that the cutting edge simply flakes away, but good carbide is pretty much all good. I found no bad carbide

Blades with a tot of teeth don't have much room for shoulders. Here are a few that failed—most likely while cutting aluminum-and were returned as 'defective' to the dealer.

on any blade except a Sears 20-tooth all-purpose ($25), which had seven teeth chipped or pitted, as shown in the photo on p. 41.

To make a tooth, the mixture of carbon and cobalt is pressed together in a mold and sintered into solid form in an oven. Teeth can be molded so close to final size that, on cheap blades, the tops alone are ground, with the faces and sides retaining the dull gray, matte finish from the mold. Avoid these. Some design approaches to shape are shown in the drawings, but I feel normal, moderate-sized teeth up to about 1⁄4 in. long are the best bet. The photos on p. 41 show nearly 20 years of grinding on my first carbide blade from Sears ($35 then, $55 now), and there's a little more life in it yet. Big teeth may promise a few more sharpenings, but you'll use a lot of power and time over the life of the blade, dragging them through the cut.

The carbide chunks are brazed into pockets on the plate's shoulders, which were cut, along with the gullets, when the plate was made. Teeth brazed directly to the front of a blade without being pocketed used to be the sign of a really cheap blade, but I found none of these. Also, I did not find bad brazing on any of the sawblades I considered for this article, so I will not dwell on the things that can go wrong—shoulders losing temper and being softened by too much heat, lack of adhesion from too little heat, serious voids, etc. It seems these are problems of the past, but that's not to say you shouldn't keep your eyes open.

The number of teeth—There's something immediately appealing about a blade with a lot of teeth. The truth is, however, that you are best off with the *fewest* teeth you can get away with for the job. The rule is that there should be at least two, but not more than four, teeth in the cut at any one time. For extended blade life, it pays to raise your sawblade high when smoothness is not important. Use the guard, of course. Lower the blade to get more teeth in the material for smoother cuts.

The more teeth, the faster the blade dulls, for three reasons: First, when there are a lot of teeth, each tooth takes small chips, which gives a smooth surface with little breakout and chipping, but each tooth hits the wood more often and the initial impact against the wood is a serious dulling factor. Second, when there are a lot of teeth, blades tend to recut the chips, in effect doing much more work than is necessary. A third factor is chip size. Good-sized chips carry away much of the heat from cutting; small chips don't. Blades with a lot of teeth run hot and cut slow.

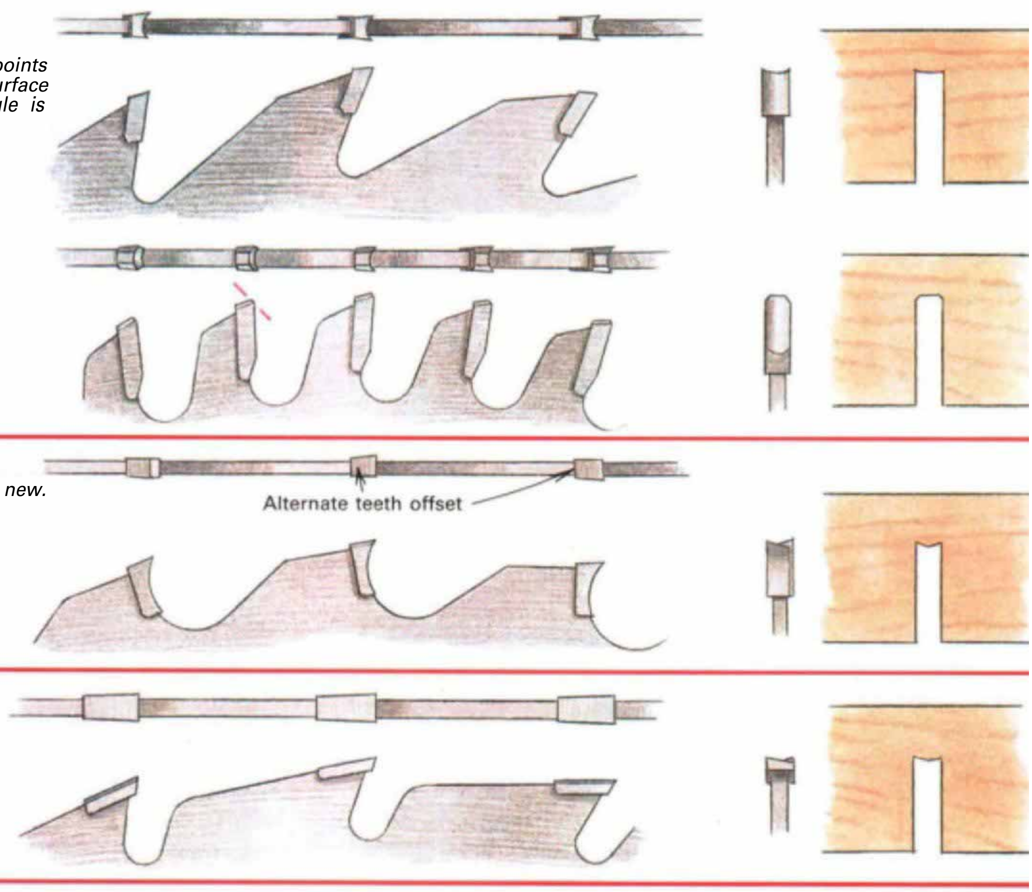
Another factor working against high tooth numbers is geometry. There's only about 30 in. around the rim of a 10-in. sawblade, and each tooth needs room for the carbide chunk, for the gullet and for the shoulder. An 80-tooth blade needs three times 80 divisions, or approximately 1⁄8 in. for carbide, 1⁄8 in. for gullet, and 1⁄8 in. for shoulder. Take a look at the damaged high-tooth blades shown in the photo above. If such a blade flutters a little,

Fig. 3: New faces

V-face or hollow face produces two points when top is ground flat-minimizes surface tearout. With triple-chip grind, hook angle is reduced at tip, for smoother-cut edge.

Hook-face tooth has high rake angle when new. Thin-kerf design cuts fast and rough.

Low-profile or horizontal tooth cuts fast and rough.



or catches an offcut or a loose knot, a tooth can find itself taking three times the impact load for which it was designed, which will break either the braze, the tooth or the shoulder. This is a particularly serious problem if you are trying to cut aluminum in a miter saw. Don't do it.

Hook angles, as shown in figure 1, are built into a blade when the plate is cut. The higher the hook angle, the more aggressive, and rougher, the cut. The lower the hook angle, the more the tooth acts as a scraper. Let's say a "normal" hook angle is 10°. A higher hook angle makes a blade act as if it had fewer teeth-it will cut faster and require less power. A lower hook angle, particularly a negative hook angle, makes a blade act as if it had more teeth. Blades with lots of teeth and low hook angles may excel on a miter saw or a radial-arm saw, where cuts are relatively short and feed pressure not too important. But if they are used on the tablesaw, they may require objectionally high feed pressure and may heat up too much on long cuts, burning the work and possibly warping the plate.

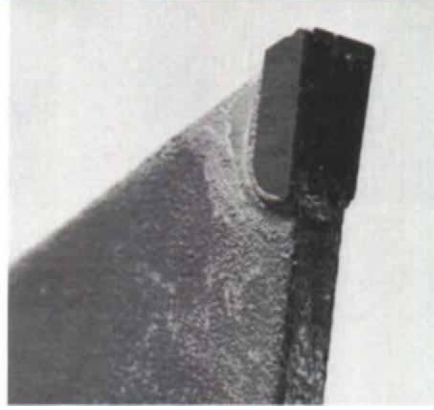
The advice to use as few teeth as possible depends on the cutting job. All else being equal, the more teeth, the smoother the cut. Rip blades usually run from 10 teeth to 40 teeth. If you have to surface the sawn edge anyway, it makes little sense to choose a rip blade with more than 20 teeth. Blades with more than 50 teeth are usually designed to crosscut wood or to saw plywoods, non-ferrous metals, particleboard and plastics, where smoothness of the cut is more important than speed and blade life.

The grind—Every cutting edge needs some elementary clearances, or relief angles, which are shown in figure 2. These allow the cutting edge to bite into the work without friction from the top and sides of the tooth. Top and side clearances are fairly standard, and there's not much to be said about them except that blades should be cleaned when pitch starts to build up in these areas. Typical cleaners include kerosene, alcohol, ammonia or oven cleaner.

Clearance between the sides of the plate and the work being cut is provided by making the teeth wider than the plate. In addition, there is usually a radial (or side-profile) clearance of typically 0.007 in. to 0.010 in. from the tip of the tooth down to the bottom of the tooth. Some planer-type blades have radial clearances of 0.001 in. and less for an especially smooth cut, rivaling hollow-ground steel blades. The two best-known contenders for an ultimately smooth cut, Forrest's Woodworker I and Freud's LU85M, take different approaches toward the goal. Forrest grinds little or no radial clearance and uses a thin plate machined to very precise tolerances to provide sufficient plate clearance. Freud's LU85M is designed to have as little plate clearance as possible, on the theory that if a tooth doesn't stick out far, it can't scratch much. The blade is therefore coated with Teflon, because in most cutting, the plate will rub. Freud includes special sharpening instructions, because if this blade is sharpened normally, all plate clearance can be lost and the blade may start to smoke. While this design approach may have its drawbacks, it makes the blade particularly appropriate for vibration-prone machinery—miter saws, radial-arm saws and tablesaws with lumpy belts, arbor run-out, out-of-round pulleys, unbalanced motors or other flaws-provided there's enough power to keep it turning.

With these obligatory clearances in mind, the simplest grind is a flat-top, flat-face rip tooth. It works like a chisel with the grain, chopping in, then popping out hefty chips. The whole edge cuts, so the blade requires considerable power, but wear is slow because it's spread across the whole cutting edge. Square teeth have a stable cutting geometry. This is offset somewhat by typically high hook angles that follow changes in grain direction, leading

This old Sears blade (left) has been resharpened many times. Although there's hardly any carbide left, the blade cuts smoother than the new one at right because it was sharpened more carefully. It also cuts easier, because the teeth have become smaller and thinner, so less carbide has to be dragged through the cut.



It's worth inspecting blades before you buy. On this Sears combination blade (about $25), seven of the 20 teeth were chipped or had pitting and inclusions. Even on costly blades, magnification may show similar sharpening damage.

to rough cuts. Like a chisel, a rip tooth cuts poorly cross-grain.

A cure for the rough cut, while keeping balance, is the triple-chip design. A leading tooth has its corners ground off so it plows a center groove, which is then cleaned up by one or more rip teeth, called rakers, that follow it. These blades are effective in particleboard or other materials that have uniform tough structure. A triple-chip blade with square rakers and a low or negative hook angle is good for non-ferrous metals, but not for cross-grain cutting in splintery plywoods. Where surface splintering is a problem, you need teeth with sharp corners to sever the work.

There are a few ways to grind points onto teeth. If a rip tooth's face is beveled, a mild point on one corner of the tooth will result because of the way the face bevel intersects the top clearance angle. Points can be put onto teeth by such exotic grinds as V-top grinds, hollow faces or concave faces, but by far, the most common tactic is to alternately bevel the tops of the teeth. This bevel can be as mild as 5° or as steep as 40° The higher the bevel angle, the sharper and more fragile the tooth.

For cutting splintery plywoods, a triple-chip tooth may be followed by two or more alternate-top-bevel teeth. Such a blade with mild top bevels will be more stable in the cut than one with high top bevels. The tradeoff in triple-chip blades is that one with square rakers may splinter the veneer, but will produce a smoother-cut edge. One with high alternate top bevels will produce a scratchier-cut edge but with no tearout, and is best for veneer, laminate or melamine. If the tearout problem is paramount, you want a blade with top bevels of between 30° and 40° Such a blade will dull fast, but the long point will still give a splinter-free cut for a longer time than a shallow-bevel blade that is in fact sharper.

Triple-chip blades are designed for man-made materials, but if they have moderate alternate-top-bevel rakers, they can be used on solid woods as well, making them something of a jack-of-all-trades. Another good all-around blade would be a 40-tooth with alternate top bevels between 15° and 20° Spokesmen throughout the industry recommend this type of blade for general-purpose cutting in the average shop. It can smoothy crosscut solid woods, plywoods, particleboard and laminates, and if not pushed too hard, can rip up to 2-in.-thick hardwoods.

The last candidate for all-purpose work is a combination blade like my old Freud, with groups of teeth consisting of four alternate-top-bevel teeth followed by a flat-top raker ground a little lower. The usual number of teeth is 50, ten groups separated by deep gullets. Because of their popularity, everybody makes a blade of this design—I tried half a dozen and thought they were all excellent-but the consensus is that you are better off buying separate blades more specifically designed for the work at hand.

Figure 3 shows a few new tooth shapes. The V-top and hollow-face grinds can be found on some very good sawblades indeed, and produce chip-free cuts in difficult plywoods and melamine. But fancy teeth on cheap blades seem aimed for the consumer market, and the generally loose tolerances necessitated by this price range mean you might get a very good blade for the money, but you might also not. A V-tooth gives a smoother cut than the number of teeth would suggest, but requires high feed pressure. The hook tooth and the horizontal tooth both cut very fast, but I wouldn't call either cut smooth.

The polish—With the grind geometry established, the next consideration is how well the carbide has been sharpened. Carbide must be ground with diamond wheels. Some shops use as coarse as 180-grit wheels, but the best shops finish with up to 600 grit. Diamond of 400 grit leaves a finish on carbide comparable to what an 80-grit aluminum-oxide grinding wheel leaves on steel. The surface depends not only on the grit size, but on the slowness of the pass, the lubricant used and the condition of the wheel. Contrary to general opinion, silicon-carbide "green wheels" do not sharpen carbide, but merely remove the cobalt binder material. They can be used to rough-shape carbide, but will not leave a true sharp edge.

A rough grind on the face, sides and top indicates that the cutting edge is ragged, and there is a good chance that the points of many teeth will be missing. Any manufacturer can have a bad day in this regard and it doesn't necessarily mean that the blade is inferior. Provided the plate is good, you'll get many years' work from it, and a good sharpening service can make the blade better than new indefinitely. A highly polished carbide surface, on the other hand, does not necessarily indicate a sharp cutting edge. It may be the result of a glazed, clogged and worn diamond wheel that has overheated the cutting edge, leaving it weak and fractured—you'll be more likely to see this on a resharpening rather than on the original grind, and I'd worry about it. The true test of a good grind is to inspect the cutting edge under magnification. You can verify this yourself very easily. Take a carbide blade that has seen some service and look for a tooth that has picked up more than its share of pitch on the top or face. I'll bet that even under low magnification, you will find the tooth's corners chipped off. By examining teeth under higher magnification, say 20X or 30X, you can tell a lot about how a blade will cut even before you mount it on the saw. □

Jim Cummins is an associate editor of Fine Woodworking