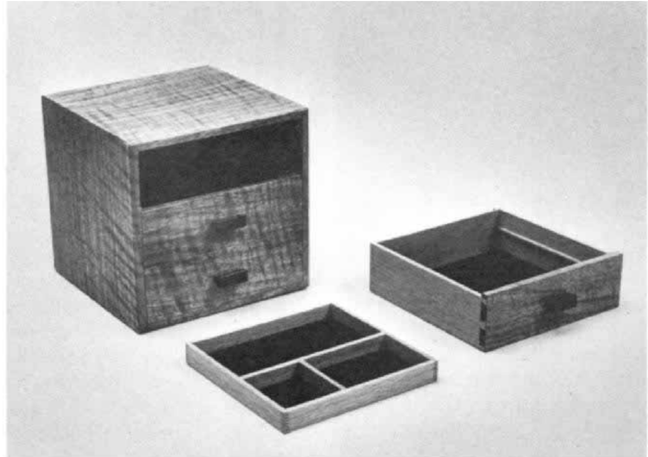
On Precision in Joinery

How close is close enough?

by Allan J. Boardman



An exemplar of precise joinery, author's full-blind finger-joined music box is 4½ in. on a side. Carcase is flame-figured butternut, dovetailed drawers are English beech with rosewood pulls.

Comparing a machine tool such as a lathe for shaping metal with its counterpart for working wood suggests that entirely different methods and standards are normally applied when operating on these two dissimilar materials. The differences are obvious—finely graduated scales and dials festoon the metal lathe, while the wood lathe probably has no measuring scales at all. What may not be obvious is the fact that woodworkers nonetheless do approach tolerances that might seem appropriate only to metal. The flexibility and compressibility of wood, the acceptability of fillers, moldings and bulk-strength adhesives, the dynamic movement of the material and the omnipresence of shoddy commercial products all contribute to the belief that "precision" is not a word in the woodworker's vocabulary. However, a close look at a truly fine piece of cabinetry will reveal some surprising facts about the dimensional tolerances inherent in its joinery.

Consider the miter joint connecting two adjacent members of a frame made from 3-in. wide stock (figure 1). If the miter were tight at one end and open, say, 1⁄64 in. (0.016 in.) at the other, the joint would be quite unacceptable. The frame would be weak, since most adhesives work best in films far thinner than 1⁄64 in. Even an untrained eye could easily detect the mismatch, and filler could not disguise it.

Most shops have lots of clamps, and all too often they are used in abundance to bend or press a joint closed while the glue dries. The result may well be a tight joint, but the structure is liable to be distorted—warped, bowed or out-of-square. This distortion may cause extra work in fitting for doors or drawers, perhaps some unanticipated cosmetic repairs, or it may even be uncorrectable and quite obvious in the finished product. And regardless of how well one compensates, the assembly will retain residual stress after the clamps are released. Built-in stress will work against the adhesive for a long time, causing the joints to creep and the dimensions to change. Stress can burst open an otherwise strong joint months or even years later. Improperly seasoned wood and changing humidity, although usually contributory, are sometimes blamed for joint failure when the real problem is faulty joinery initially hidden by clamping pressure. In first-class work, there is no substitute for joints that fit properly.

In figure 1, note that the angle of the tapered space in the miter joint is less than a fifth of a degree. The tolerance in a good miter might be 1⁄10 of that, or barely 1 minute of arc. With such a fit, the open end of the tapered gap would be less than 0.002 in., or about half the thickness of a piece of paper. This, in most cases, would be acceptable from the standpoint of strength and appearance. But measurement and tolerances in thousandths of an inch and minutes of arc sound like the language of machinists, not woodworkers. After all, many of our measuring devices are themselves made of this changeable stuff, wood. The protractor scale on a woodworking machine goes no finer than one degree—minutes of arc, never. Parallax caused by the distance between pointer arrow and protractor ensures significant error, depending on where you hold your head. Does no one expect a woodworker to hold to a small fraction of a degree, except perhaps at 90° and 45°, where some machines have detents?

Allan Boardman, 46, of Los Angeles, is an aerospace systems engineer and lifelong amateur woodworker.

So it is with lineal dimensions too. For the seasoned worker, tricks, techniques, experience and feel (not mutually exclusive terms) compensate for the limitations of the equipment. But to the beginner, the not-quite-square square, the coarse graduations of scales and protractors, the machine's structural flexibility where rigidity is desired, all subtly suggest that only this crude level of accuracy is to be expected. Worse, because of careless use of words like "precision," "accurate," "professional" and "heavy duty" in advertising, the novice comes to believe that plus or minus a thirty-second is precise or that the machine by itself guarantees precision. Consequently, beginners may set personal standards for quality far lower than they should and progress far too slowly in the acquisition of those skills and techniques needed to overcome tool limitations.

Tool quality, measuring and marking—The limitations of our tools are not all bad, once recognized and understood. If a manufacturer were to add the weight, rigidity and precision some of us dream about, the cost of tools would rapidly become prohibitive. Also, because of the properties of wood, some of this extra precision would be wasted: The skilled maker would still have to compensate for the peculiarities of each species and piece.

Some tool limitations may require us to take lighter cuts, and they may inhibit some design options or demand greater skill, but by one means or another, we live with the available tools. Nonetheless, the first thing we must do is correct what can be corrected. For example, a framing square can be made quite true simply by peening the metal at the corner (*FWW* #17, July '79, p. 15). Likewise, cabinetmaker's squares having a metal blade and wooden stock can be filed true. Bench planes require all sorts of fine tuning before one can realized their full potential (*FWW* #14, Jan. '79, p. 52).

Leaving aside heavy-duty production machinery, one should not take for granted the implied precision or quality of tools. If you have the time and patience (and the indulgence of the shopkeeper) to examine and compare all of the squares, planes or chisels in stock, you may find one that is better than the others. The common test for a square, for ex-

Photo: Allan J. Boardman

ample, is to mark a line on wood or paper taped to the counter, then flop the square over to see if the blade lines up with the line (figure 2). Any discrepancy is double the inaccuracy of the square. But realize that you will have to spend time on most tools to make them right.

So how do you make them right? Against what do you check for square? There is no way around it: Every shop needs a reliable standard for straight, square and flat. A quality machinist's combination square is a good investment because it provides a reliable 12-in. straightedge, an accurate square and a 45° reference. A 3-ft. metal straightedge is useful and is available at some woodworker and most machinist supply houses. One can also buy a strip of flat tool steel and have a machine shop grind it true. The top of a quality table saw should be flat enough to serve as the reference surface, but it is best to check this if possible by removing it, toting it to a machine shop for measurement and, if necessary, having it ground. Other flat references are granite surface plates and slabs of heavy plate glass or marble, which are generally quite flat but must also be checked. The rule of thumb is that these shop standards should be five to ten times better than anything you are likely to check with them. It is also desirable to have at least one fairly large bench surface be rather flat, say within 1/64 in. over a two or three-foot square, for layout work. This can be prepared with a jointer plane and checked with your reference flat, by rubbing one surface against the other through carbon paper. If your reference surface is not easily moved and inverted, use winding sticks instead (figure 3).

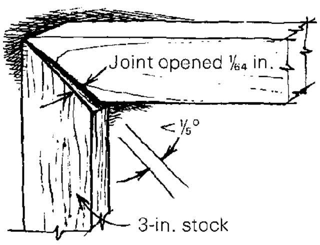
An accurate ruler or scale is also important. Simply because a stick or tape is marked in inches and fractions, it does not follow that the marks are where they should be. Some steel tapes are off as much as 1/8 in. in 10 ft. The machinist's combination square will provide a reliable 1-ft. scale against which others in the shop can be calibrated. The graduations are generally fine and deeply engraved for long life.

These points are about absolute accuracy. More important, most of the time, is relative accuracy. Once the dimensions of a given piece are quite close, the requirement for fit outranks the requirement for hitting the exact dimension on the nose. Consider cutting the four moldings for a picture frame. First, the pieces must be near to the desired length. Second, each piece must be the same length as its opposite, and third, after mitering, the corner joints must be tight (figure 4). Because the molding might not be perfectly true or straight, we trim the miter to fit, and as a result the mating surfaces may be a fraction of a degree off the nominal 45°, or one of the sides may be a deliberate but imperceptible fraction shorter than its opposite. A tiny variation in dimension cannot be observed, whereas an open joint will always be visible and weak. At the stage of final fitting, the ruler or gauge becomes a superfluous intermediary, an unwanted source of error.

This notion of dimension giving way to fit is not radical. It is like the intuitive procedure we use when setting a tool or machine whose protractor or scale has only coarse graduations. We guess at a setting someplace between two markings and then, ignoring the actual number of degrees or thousandths, we make small adjustments by trial and error, perhaps with a piece of scrap, until the fit is just right.

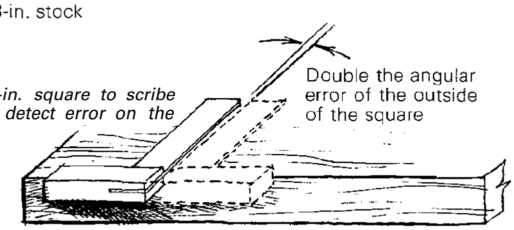
Marking can be done with a sharp pencil, but when the position of the mark impacts final fit, a marking knife should be used. Not only will the line be narrower and therefore better define the position, but a knife will lie much closer to the

Figure 1



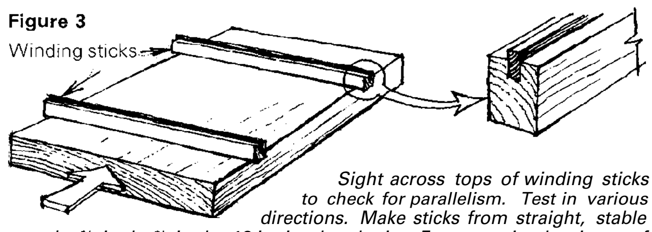
In a frame made of 3-in. stock, a total error of 1/5° in cutting the miters will cause a 1/64-in. gap in the joint. This could result from an error of only 1/10° in setting the saw or in using the miter box, or from warped wood, or even from a tiny chip lodged between the fence and the work. To avoid the error, woodworkers cannot rely on the gross measurement that machine scales provide.

Figure 2



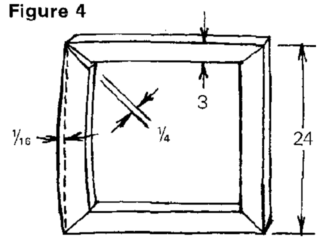
Flopping a 12-in. square to scribe two lines will detect error on the order of 1/20°.

Figure 3



Sight across tops of winding sticks to check for parallelism. Test in various directions. Make sticks from straight, stable stock—1/2 in. by 3/4 in. by 18 in. is a handy size. Fancy version has insert of light wood in one stick, dark in the other, for better visibility. Well-made sticks used carefully can find 1/10° of error.

Figure 4



Even though all the angles are cut at exactly 45°, if three of the frame pieces are straight and the fourth bows just 1/16 in., over a length of 24 in. the joint will open about 1/4 in. Such an error is usually corrected by clamping pressure, but it's often better to adjust the angles as necessary and get tight joints without heavy pressure.

gauge, square or piece used in marking. Furthermore, the mark, being a physical incision in the wood, can often be used to position a chisel for the next operation. A typical example would be marking the shoulder line on a tenon to be cut with hand tools. The knife cut serves simultaneously to locate the shoulder edge, neatly sever the surface grain, and guide a chisel to create a starter groove for the tenon saw.

Cutting to the line—So much for measuring; the marked piece must now be cut. Precision in cutting is the exclusive domain of neither hand nor power tools. I say this despite diehard traditionalists who would argue that truly fine work can be done only by hand, and despite power-tool proponents who believe a plane is what you'd be forced to use if you couldn't afford a machine. There is seldom one best way. A proper table-saw setup would save time if a number of identical tenons were to be cut. The hand-tool method might be best for only one joint, if several different pieces are required or if the shoulder is not perpendicular to the rail.

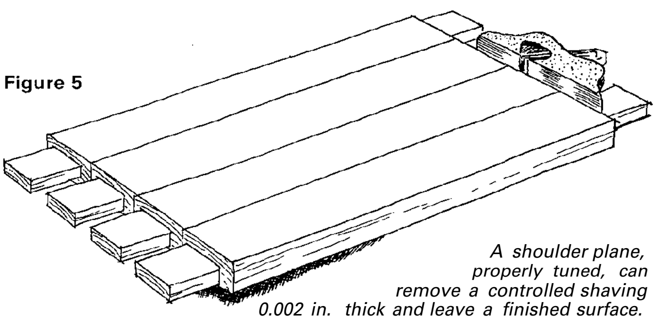
Often, a combination of hand and power tool methods offers optimum results, taking advantage of the best characteristics of each tool. Suppose tenons are cut at each end of a stile, but for some reason the distance between the tenon shoulders is just a bit fat. (This can usually be avoided by checking with scrap before cutting the work itself.) Moving the table-saw fence a controlled 1/64 in. is tricky. And unless it has just been sharpened, a circular-saw blade is not too effective in trimming off the merest hair. The wood may burn or the blade may deflect, leaving a cocked, charred shoulder.

It is undeniable that power tools save time and physical exertion, but some cuts in precision joinery, such as shaving off that minute error, are clearly better performed with hand edge tools—planes in particular. In practiced hands a shoulder plane can trim that miscut tenon down to size in seconds. End-grain shavings as thin as 0.002 in. can be produced, enabling the scribed line to be approached under the watchful eye of the maker (figure 5). It makes little difference if the waste to be removed is straight or tapered. Because of these factors, it is often advisable when using machines to leave a little margin for hand trimming.

Planes do not cut like most power tools, virtually all of which cut intermittently, pounding on the wood fibers and doing inescapable damage on every cut surface (for a close look at the surfaces left by various cutting tools, see *FWW* #21, March '80, p. 52). The unique action of the plane with or across the grain, however, severs the wood fibers cleanly in a continuous, not intermittent, motion. The finished surface in many cases cannot be improved upon. The damaging forces involved in parting the waste from the work are absorbed by the shaving as it breaks or curls. The planed surface, except where the wood grain is particularly cantankerous, shows no evidence of the trauma. Even more important for precision is the fact that the plane can leave a good surface after each pass. The perfect fit can be approached by increments and when achieved, no further clean-up is required. In many routine joinery operations, this objective is far more difficult to reach with sandpaper, files, saws or routers. And as a bonus, all this control comes with no great sacrifice in speed. A plane stroke takes only a couple of seconds.

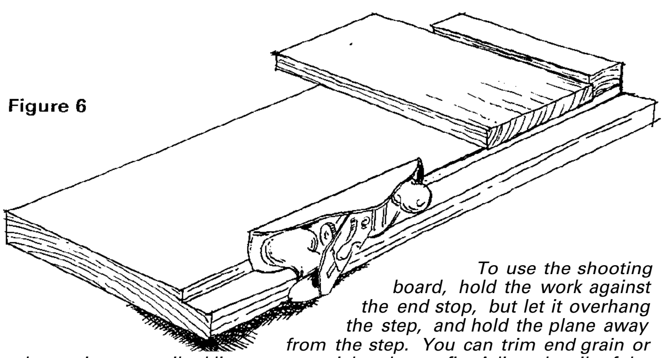
Paring with chisels and other edge tools offers similar possibilities for working toward precise joints, particularly where the geometry prohibits using a plane. Here the control afforded rather automatically by the plane must be provided by the craftsman. However, the principle is the same—taking off just as much waste as desired, exactly where desired, and leaving a clean surface after each cut.

Figure 5



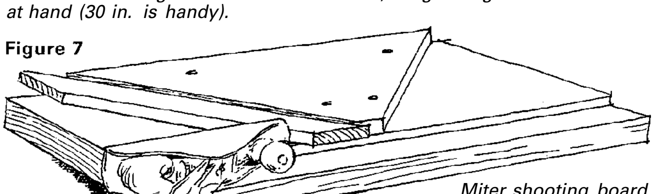
A shoulder plane, properly tuned, can remove a controlled shaving 0.002 in. thick and leave a finished surface.

Figure 6

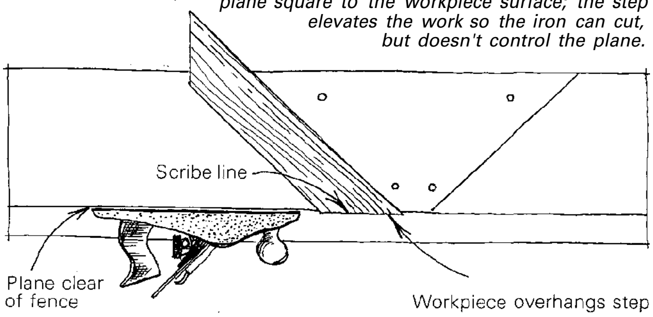


To use the shooting board, hold the work against the end stop, but let it overhang the step, and hold the plane away from the step. You can trim end grain or edge grain to a scribed line, or to a trial-and-error fit. Adjust the tilt of the plane iron to keep the cut surface perpendicular to the face of the board. Make the shooting board from stable wood, long enough to suit the work at hand (30 in. is handy).

Figure 7



Miter shooting board can trim any angle near 45°. The jig serves as a stop and holds the plane square to the workpiece surface; the step elevates the work so the iron can cut, but doesn't control the plane.



Jigs—The criteria I apply to virtually all joints are first, in hidden interfaces (the tenon in the mortise) there should be only enough clearance for a thin glueline; and second, visible interfaces (miters, for example) should appear tight with only light clamping. As you approach the final fit a shaving at a time, you quickly discover the need for devices that help keep the hand tools perpendicular, free from wobble, or otherwise aligned. Jigs and fixtures do not guarantee precision, but they can reduce the degrees of freedom the tool has so the craftsman can exercise greater control toward getting the fit.

A jig of continuing use is the shooting board—nothing more than a flat piece of stable wood with a step at the edge and a stop near one end (figure 6). With it, one can simultaneously plane an end or edge of a piece exactly to a scribed line, straight and perpendicular to the surface. Using this same jig and a little blocking or intentional tilt of the plane blade, angles other than 90° can easily be cut for coopered joints or simply to compensate for some special condition.

Other jigs in this same family include several versions of the bench hook, and the miter shooting board—the solution to the problem that began this essay, of how to adjust a miter angle by a fraction of a degree (figure 7). In use, the plane is laid on its side on the ledge while the work is held against the 45° stop. If the plane body is out of square (it usually is), the mitered surface will not be perpendicular to the face of the piece. This can be corrected to some extent by adjusting the tilt of the plane iron, by shimming the work, or maybe 91° is really desired. The 45° angle (or 44° or 46°20') is not a result of holding, the plane firmly against the step in the fixture while pressing the work against the fence. Of course, it could be if the jig were made exactly at the angle desired, but that is too restrictive a use of the shooting board. Rather, one holds the work against the stop but overhung, and the plane sole away from the step. One then planes either to a scribed line or by trial and error to a perfect fit with the mating piece.

In contrast to such "permanent" devices, many simple jigs

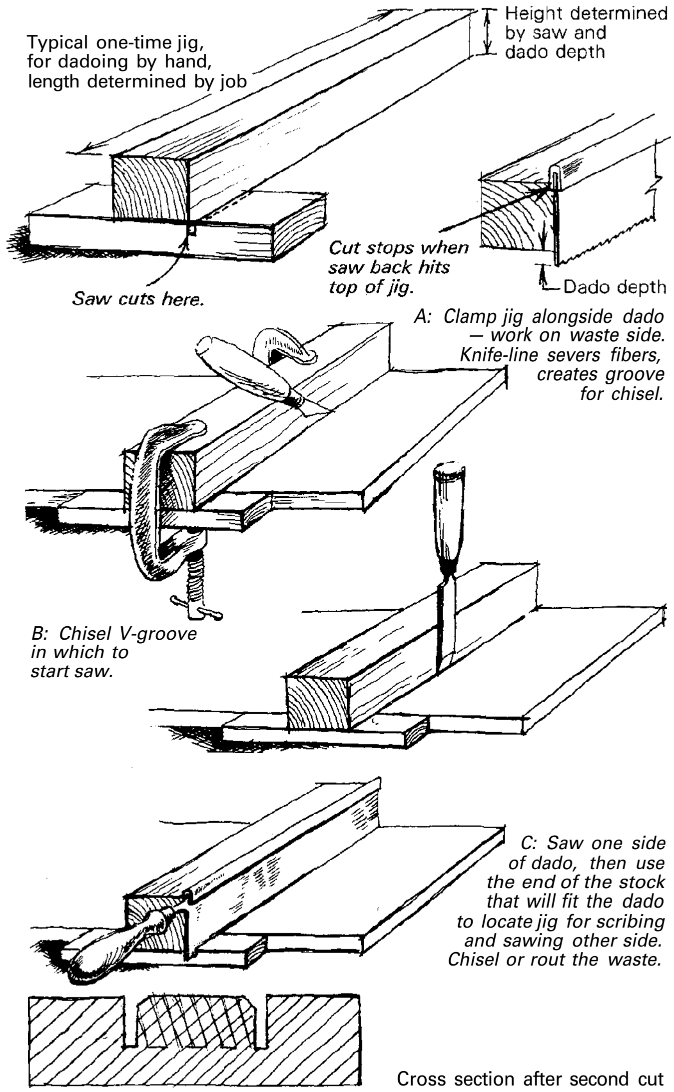
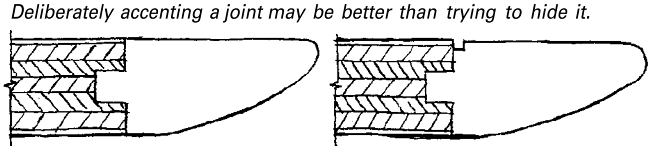


Figure 9

Deliberately accenting a joint may be better than trying to hide it.



Planing, sanding or scraping solid banding flush may damage veneer.

Scratched or sawn groove highlights joint, reducing need for precision.

can be made for short-term use. The usual reasons such jigs fall into the disposable category are that they get worn or damaged in use or are special in nature or dimensions. Consider cutting dadoes by hand in the two vertical sides of a bookcase (figure 8). A useful multipurpose jig fashioned from two pieces of wood not only simplifies the operation but also facilitates precision. In appearance, the jig is nothing more than a clumsy-looking square, the long leg reaching across the workpiece, the short leg attached accurately at right angles. The width of the members should ensure stiffness and rigidity. The thickness of the short leg should be a trifle less than the workpiece thickness so as not to interfere with clamping. The thickness of the long leg must be sufficient to keep the backsaw perpendicular, but it can also be such that when the saw back hits the jig, the cut is at the desired depth. The jig is clamped to the workpiece and at the one setting serves as a straightedge for scribing, a control for chiseling out a starter groove for the backsaw, a fixture for holding the saw upright, and a depth stop. Two such sequences per dado, followed by cleaning out the waste with chisel or router plane, leave an exceptionally clean joint the width of which can exactly fit the thickness of the shelf. With this method it matters little that the shelves vary in thickness from one to another, or that the dado head on your power saw cuts only in fixed increments that don't match your wood. Notice that in this example since all the scribing and sawing are done on the waste side, both long edges of the jig are used and so must be parallel. Obviously, the same basic technique can be adapted to other and more complicated joints—stopped dadoes, rabbets and dadoes, tapered dovetails and so on.

Precison is relative—In woodworking there is a scale of precision demanded by the nature of each project, from rough to finish carpentry ascending through built-ins to fine cabinetry, furniture-making and ultrafine craft objects like view cameras. Tolerances might range from plus or minus an eighth to one or two thousandths. In addition, we must superimpose a scale of functional tolerances that takes into account the size of the object and the wood's probable movement in response to changes in temperature and humidity. The "precision fit" of a drawer in a fine chest incorporates a neat but wider clearance gap than one would find around the drawer of an equally well-made jewelry box.

Finally, one should not neglect the many different design options that shift the need for one kind of precision to another, or eliminate the need altogether. The results can be quite acceptable and are normally found in abundance on commercial work. Take, for example, the use of a solid nosing around the top of a veneered cabinet (figure 9). To blend the grain of the solid piece with the veneered panel and to join it flush without damaging the thin and delicate veneer would involve considerable skill and risk. This requirement can be virtually eliminated by accentuating the seam instead of hiding it, with a routed or scratched groove used as a design feature. Likewise, moldings can effectively mask imprecise joinery, and overlapping fronts can conceal uneven clearance around cabinet drawers. With design skill, such techniques can permit production shortcuts. Often, they are the best choice in purely design terms, and the fact that less precision is required becomes a bonus.

The characteristics that denote precise woodworking are not limited to joint accuracy and fit. They also include grain and color matching, uniformity of detail and symmetry when intended, clean pre-finish surface preparation, crisp installation of inlays and fittings, minimum use of fillers, and so on.

Precision in joinery is neither for everyone nor for every project. It can be an objective or an attitude that adds pleasure to the craft and quality to the work. It can, on the other hand, become an obsession that goes beyond common sense to the point of inconsistency with the nature of wood itself. But it seems far better for a woodworker to understand the options, recognize that certain skills and techniques can be invented or learned, know what is possible to accomplish, and then exercise free choice, rather than have his or her standards derive from crude scale markings and constant exposure to mediocre work. □