Abnormal Wood

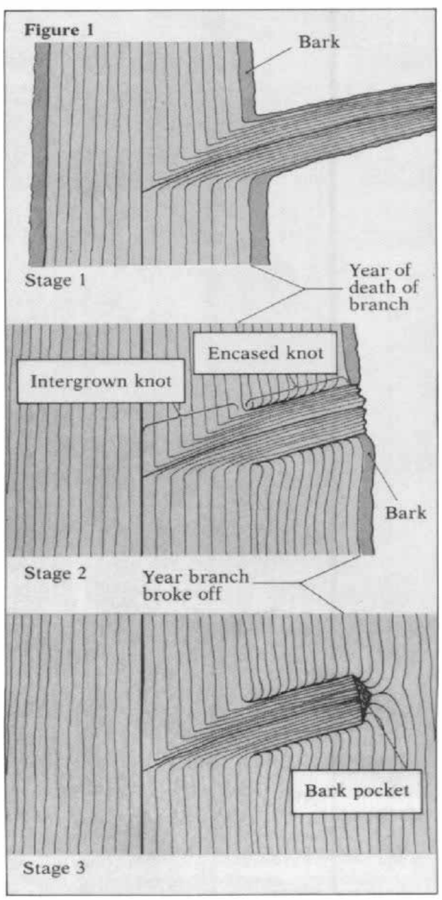
Dealing with knots and reaction wood

by R. Bruce Hoadley

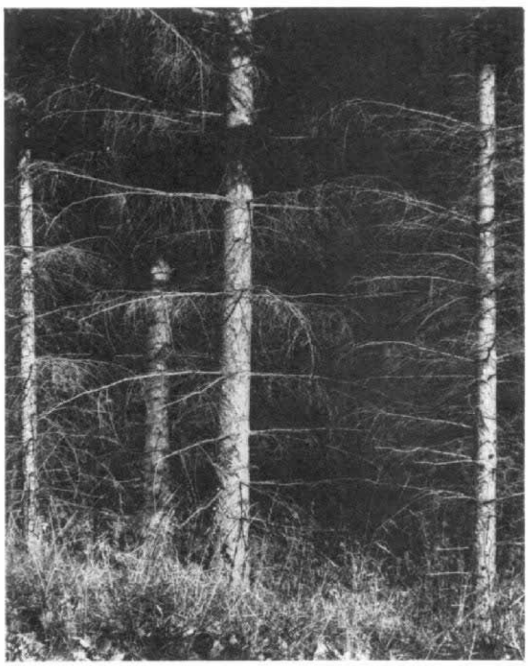
While some irregularities in wood may increase value, as when a distinctive figure is produced, others decrease value. By tradition, any irregularities that decrease value are branded as defects. Although some of the features described below seem to be negative in woodworking, the woodworker is urged to reserve judgment on nature's irregularities. These were indeed defects when hand tools could not deal with them, but now many of these irregularities can be routinely machined using power tools.

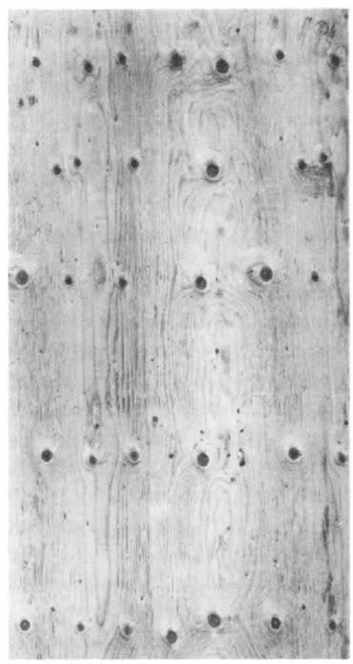
Knots—The commercial hardwood lumber-grading system assumes that every knot is a defect and bases grade on the size and number of clear areas among the knots (and other blemishes). On the other hand, many beautiful works of craftsmanship and art have been produced using, or even featuring, knots. The woodworker should first of all understand what knots are and how their structure relates to the rest of the wood. Knots are simply the parts of limbs that are embedded in the main stem of the tree (figure 1).

As the tree grows, branching is initiated by lateral bud development from the twig. The lateral branch thus was originally connected to the pith of the main stem. Each successive growth ring or layer forms continuously over the stem and branches, although the growth ring is thicker on the stem than on the branches and the branch diameter increases more slowly than the trunk. As the girth of the trunk increases, a cone of branch wood—**the intergrown knot**—develops within the trunk. Such knots are also termed **tight knots** because they are intergrown with surrounding wood, or **red knots,** especially in conifers where they often have a distinct reddish tinge. At some point the limb may die, perhaps as a result of overshadowing by limbs higher up. The limb dies back to approximately the trunk surface, its dead cambium unable to add further girth. So subsequent growth rings added to the main stem simply surround the dead limb stub, which may begin to rot. A number of years of growth may be added to the main stem, surrounding the branch stub. The dead part of the stub becomes an **encased knot.** It is not intergrown and therefore is also called a **loose knot,** often with bark entrapped. Knotholes result when an encased or loose knot falls



A knot is the basal portion of a branch whose structure becomes surrounded by the enlarging stem. Since branches begin with lateral buds, knots can always be traced back to the pith of the main stem.





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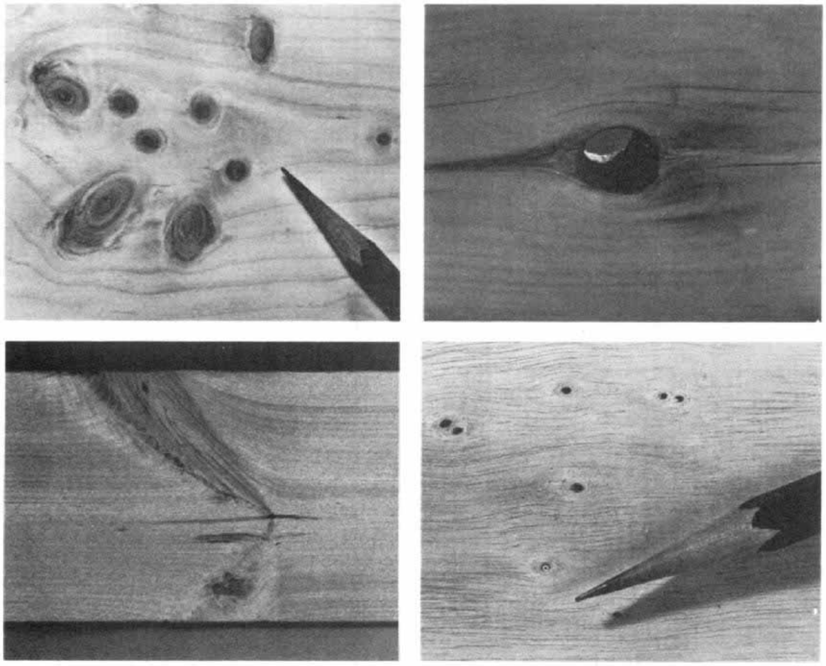
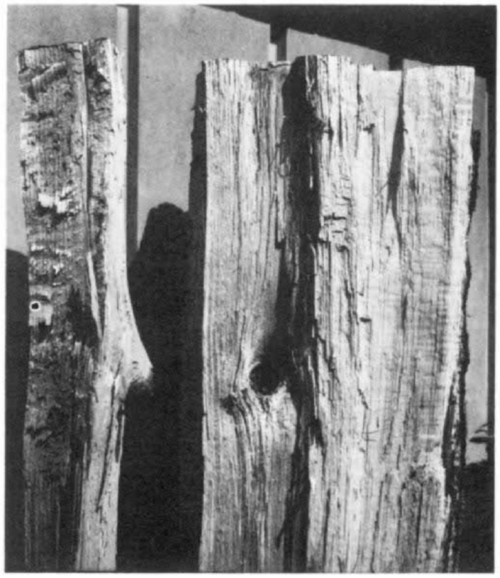
Coniferous trees, left, are characterized by excurrent form, i.e., a dominant stem from which whorls of lateral branching occur at regular intervals, or nodes. The pattern is often present on plywood made from rotary-cut softwood veneer, right.



Knot types (clockwise from top left): tight round, loose round (knothole), pin, and spike.



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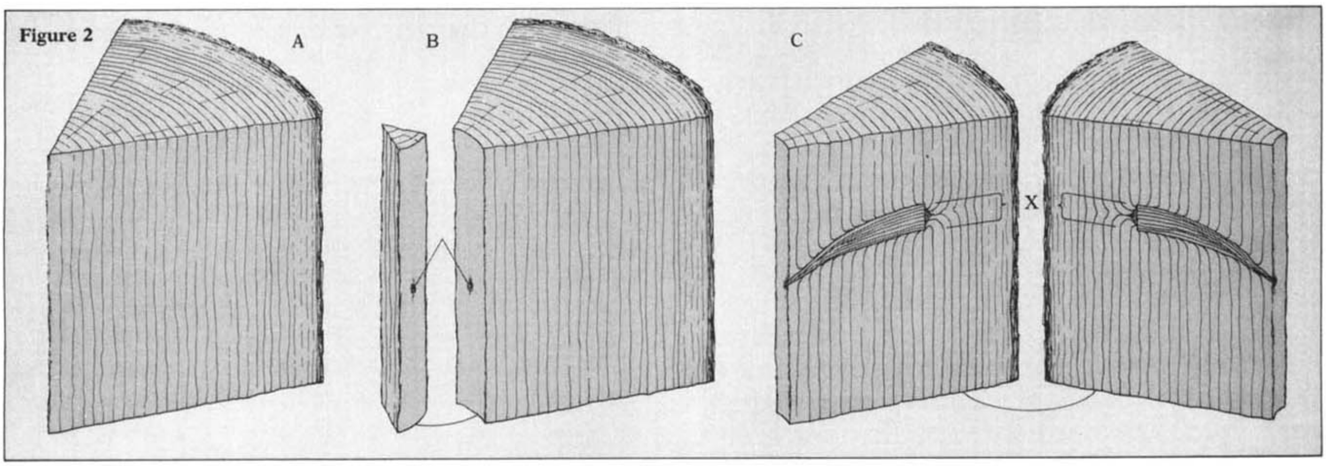
A carving chunk may appear flawless at first glance (A *in drawing below). Removing wood adjacent to the pith* (B) *will locate internal knots* (C *and photo above). Scan in the bark (at* X) *may be a sign of knots large enough to ruin the block for carving.*

Figure 2



out of a board. Encased knots are also called **black knots** because they commonly are discolored by stain and decay. In time the stub may become weakened by decay and fall or be broken off, or it may be pruned back flush with the trunk. Further growth layers will enclose the stub, and eventually the cambium will form a continuous layer. From this point on, solid layers of wood and bark will be formed beyond the overgrown knot. But as the cambium moves outward, the knot-scarred bark layers persist for an amazing number of years, providing a clue to the buried blemish.

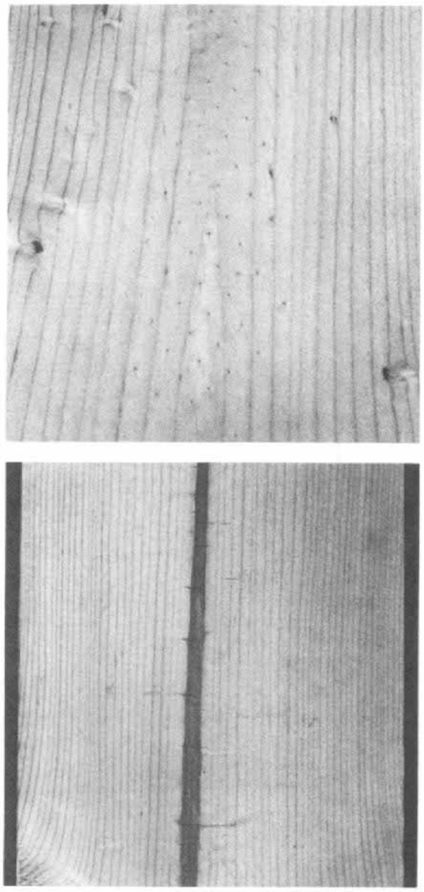
Knots may be classified by how they are cut from the tree. If they are split by radial sawing and extend across the face of the board they are termed **spike knots.** On flatsawn boards they usually appear round or oval and are called **round knots.** Knots smaller than ¼ in. in diameter are called **pin knots.**

Understanding knots can be useful to the woodworker. Nothing is more devastating to a carver than to work halfway through a block of wood only to uncover an interior knot flaw. Yet the trained eye can usually predict such a blemish. If a wedge is taken from a log and the first few growth rings near the pith are removed (figure 2), any branches will be seen at least as tiny knots. If none are present, there will be no knot-related defects in the piece. If any are located, the bark should be carefully examined for scars. Experience can tell much about the size and depth of such defects.

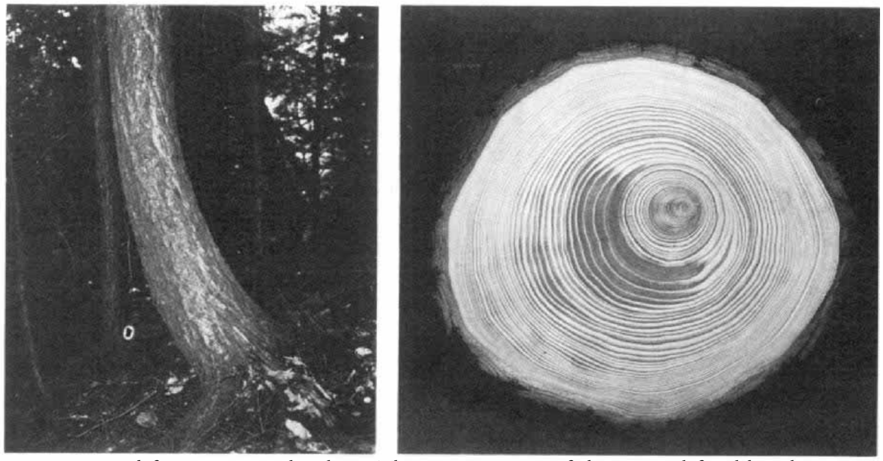
Since every knot originates at the pith, every knot that appears on the bark side of a flatsawn board will also appear on the pith side of that same board. On the other hand, some knots on the pith side may have ended and grown over before reaching the bark surface. Therefore, the bark side is often the clearer, higher-quality face.

There are a variety of reasons why knots commonly are considered defects. The wood of the knot itself is different in density (usually higher), and its grain orientation is more or less perpendicular to the surrounding wood. Because shrinkage is greater across the knot than in the surrounding wood, encased knots may loosen and drop out. Although intergrown knots remain tight, they may develop radial cracks. Encased knots are usually considered worse defects because of the discoloration and the entrapped bark associated with them. From the standpoints of strength and machining properties, the disorientation of grain direction is troublesome not only because of the knot itself but because the entire area is influenced by the knot. For example, a spike knot extending

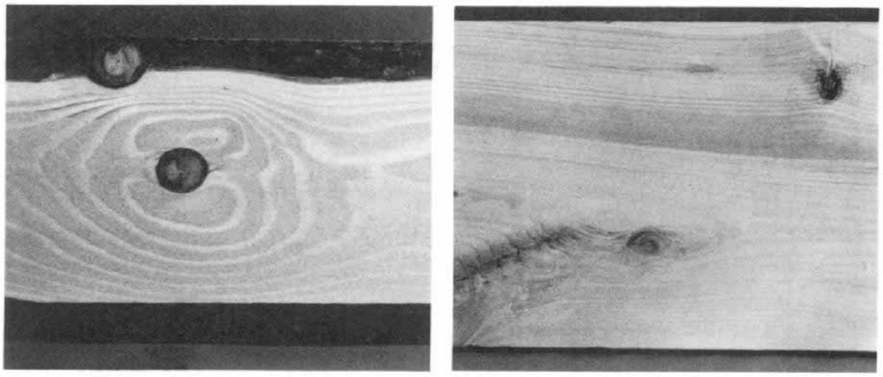
Photos, except where noted: Richard Starr



Top, wide growth rings surrounding the pith are juvenile wood, which is lighter and weaker than narrow-ringed mature wood. Needle scars also indicate juvenile wood.



Reaction wood forms in trees that lean. The curving sweep of the tree at left, although picturesque, means that unpredictable compression wood will be found within. Right, pronounced reaction wood from leaning hemlock tree, shown in cross section.



Abnormal appearance of earlywood and latewood on a flatsawn surface, left, indicates compression wood. Compression wood in white pine may appear as a dark streak on a flatsawn board, right.

across a board may cause it to break in half under small loads.

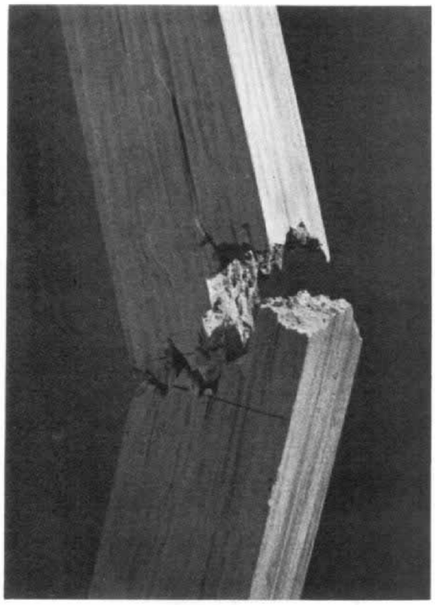
Knots may also be an asset, and have been valuable features of figure in many ways. Knotty pine is often thought to be characteristic of Colonial decor, though in reality, knots were mostly avoided, plugged or painted over by early cabinetmakers. Knotty pine as wall boarding seems to be a 20th-century invention to use the increasing stocks of common grades of lumber. Other species that exhibit knots with some degree of regularity, such as spruce, cedar and other western softwoods, have been successfully marketed to feature their knots. Individual pieces of wood with knots increasingly are fashioned into masterpieces of cabinetry and sculpture.

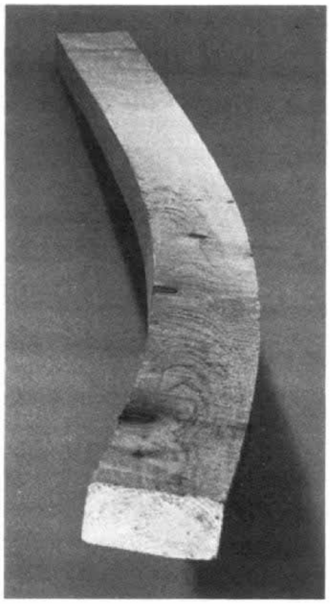
Juvenile and reaction wood—The first few growth rings added around the pith may not be typical of the mature wood formed by the tree. This core of atypical tissue is termed **juvenile wood**. It is prevalent among conifers, especially plantation-grown trees, which grow rapidly until crown closure, when competition with other trees slows growth to a more normal rate. Juvenile wood is characterized by wider growth rings of lower-density wood and less strength. It may also shrink abnormally, resulting in greater tendency to warp, especially by twisting. Pieces of wood including (or very near) the pith should be suspect. Some trees and species show little or no juvenile-wood abnormality.

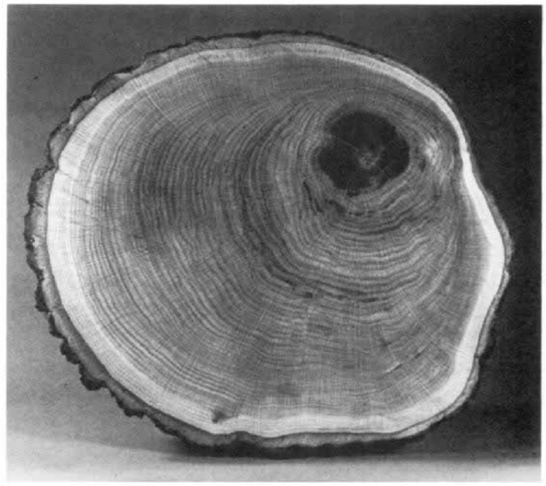
Reaction wood is a term applied to abnormal wood formed in tree stems and limbs that are other than erect, that is, parallel to the pull of gravity. The principal concern to woodworkers is the occurrence of reaction wood in leaning trunks from which otherwise defect-free wood might be expected. Causes for leaning stems include partial uprooting by storms, severe bending under snow or ice, and tree growth toward sunlight available from only one direction. Reaction-wood formation seems to include a mechanism for redirecting stem growth to the vertical, resulting in a bowing of the stem. Therefore boards or pieces from a log with noticeable bow should be suspected of containing reaction wood and should be examined very closely for it.

Reaction wood has different traits in softwoods and hardwoods. In softwoods, reaction wood forms mainly toward the underside of the leaning stem. Because the pull of gravity presumably puts the lower side of the leaning trunk in compression, reaction wood in conifers is termed **compression wood.** The part of the growth ring containing reaction wood is usually wider than normal, resulting in an eccentrically shaped stem with the pith offset toward the upper side (photos, above). The abnormal tracheids usually appear to form wider than normal latewood. Even-grained woods, such as eastern white pine, therefore appear uneven-grained. However, in woods that are notably uneven-grained, such as southern yellow pine, the latewood is duller and more lifeless than normal and tends to even out the contrast.

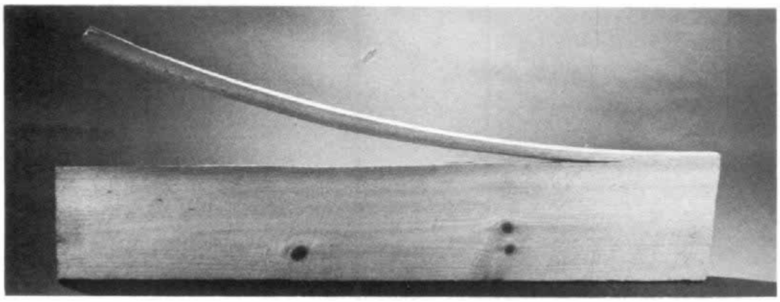
The two main disadvantages of compression wood for the woodworker are its effects on strength and shrinkage. Since



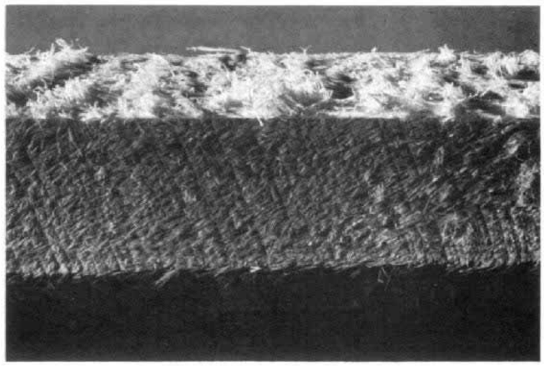




Eccentric rings on cross-sectional surfaces of red oak log indicate tension wood.



Strength and shrinkage of reaction wood are unpredictable. Brash failure, top left, can be disastrous. Abnormal shrinkage in compression wood, top right, is a frequent cause of warp. Above, reaction wood on edge of pine board has split and bent away.



The abnormal fibers of tension wood, containing a greater-than-normal amount of cellulose, left a woolly surface on this cottonwood board when it was sawn from the log.

reaction-wood tracheids are thick-walled, the wood is usually denser than normal. But because they contain less cellulose, and the cellulose chains are not parallel to the long direction of the cells, the wood is weaker than normal. The woodcarver is especially aware of the abnormally hard but brittle qualities of compression wood. In finishing, compression wood may not stain uniformly with normal wood. The carpenter notices the difficulty in driving nails and the greater tendency to split. For structural uses where load-bearing capability is vital, as in ladder rails, unknowing use of reaction wood has resulted in fatality, because the wood breaks suddenly when bent, and at lower-than-expected loads.

Abnormal longitudinal shrinkage is the second major problem. Normal wood shrinks so slightly along the grain that it is usually negligible. Compression wood shrinks up to 10 to 20 times the normal amount. What's more, because reaction-wood formation is non-uniform in a given board, the shrinkage is uneven. Drying of reaction wood, or changes in moisture content, creates uneven shrinkage stresses in the wood. This, along with juvenile wood, is a major cause of warp in framing lumber. Most distortions that develop in stud walls probably result from reaction wood. In woodworking, attempts to ripsaw pieces containing reaction wood may result in the wood's pinching against the saw or its splaying widely apart as the cut progresses, both potentially dangerous occurrences.

In hardwood trees, reaction wood forms predominantly toward the upper side of the leaning stem. Because gravity causes the upper side to be in tension, it is termed **tension wood.** In hardwoods, however, there is less tendency than in softwoods for the pith to be off-center in the stem, and tension wood may develop irregularly around the entire stem. Tension wood is often quite difficult to detect. Sometimes it looks silvery, other times dull and lifeless, and in some cases there is little if any visual difference. Indications of crookedness or sweep in the log are signals of possible tension wood. The abnormal fibers of tension wood actually contain a greater than normal amount of cellulose. This wood is commonly stronger than normal. Of concern to the woodworker is the way this wood machines. Fiber structure does not sever cleanly but leaves a fuzzy or woolly surface. Aside from the immediate problem of machining tension wood, seemingly successful efforts to smooth the wood leave a microscopic woolliness upon the surface. Upon finishing, stain is absorbed irregularly and the surface appears blotchy. As with compression wood, longitudinal shrinkage in tension wood is both irregular and greater than normal, resulting in warping and machining problems. □

This article is excerpted from the chapter "Figure in Wood" in Hoadley's book, Understanding Wood: A Craftsman's Guide to Wood Technology *($18, hardcover; 272 pp.), published last fall by The Taunton Press, 52 Church Hill Rd., Box 355, Newtown, Conn. 06470.*