"Reading" Tool Marks on Furniture

by Don Williams

The process of producing lumber from a tree to a log to a cabinetmaker or joiner always leaves physical evidence you can "read" from the surfaces of the lumber. As observers and caretakers of artifacts fashioned from these materials, it is vital for us to understand those marks so that we can consciously study the creative processes and preserve their physical evidence. There are three historical principles that explain this transformation from raw material to an intermediate usable form, and the attendant technological evidence. The first is the desire to most efficiently extract a maximum amount of semi-finished material for the cabinetmaker from a finite raw material source, namely a log. The second is that cutting big pieces into little pieces makes them easier to move and handle. In a world of manual labor, making big pieces into little pieces is a giant leap forward in production efficiency. The third, and perhaps most important, is the diminution of ultimate labor costs because it is the first step in the standardization of material and the precision of work.

Pre-industrial, or Human-powered Processes: The Fundamental Difference

It is important to point out the difference between hewing and sawing, the specialized processes for the woodsman and the sawyer. Hewing is the chopping away at a piece of wood to change the characteristics —read: dimensions—of the outside. Hewing also relates to timbering, or working with big pieces of wood. Sawing is cutting up pieces of wood with a saw, and is more frequently referred to as lumbering. Secondly, it is critical to identify the technology in question as being human powered and controlled or machine powered and controlled. In a pre-robotic age, while each tries to mimic the other, neither can fully succeed. That is our ace in the hole.

Hewing

After the tree is felled by a felling axe or sawn down with something like a two-man timber saw, and removed from the forest, the process of preparing the wood begins. In true hewing, the outside of the log is cleaned up with peeling and cutting tools. This may be

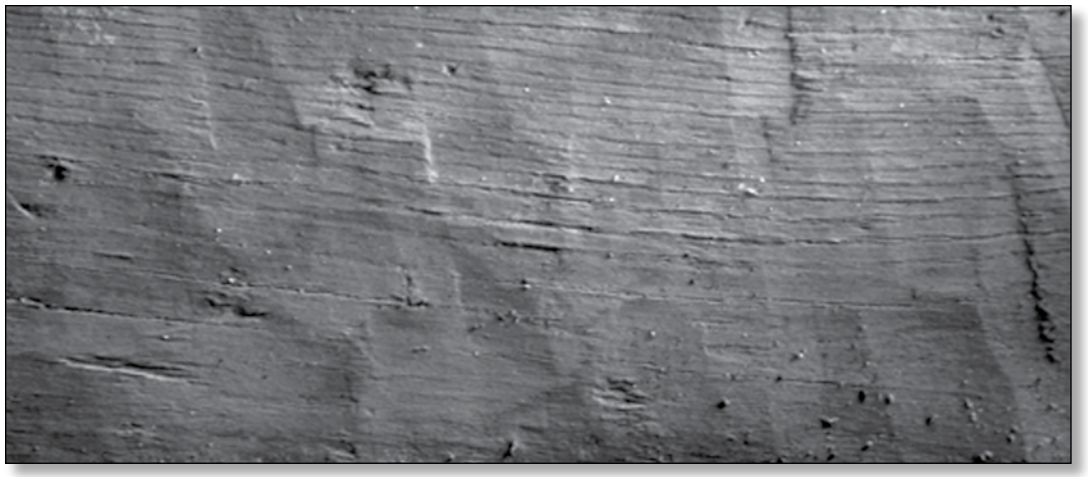


Figure 1 (right, top). The most common method of using an adze is chopping hoe-like on the workpiece.

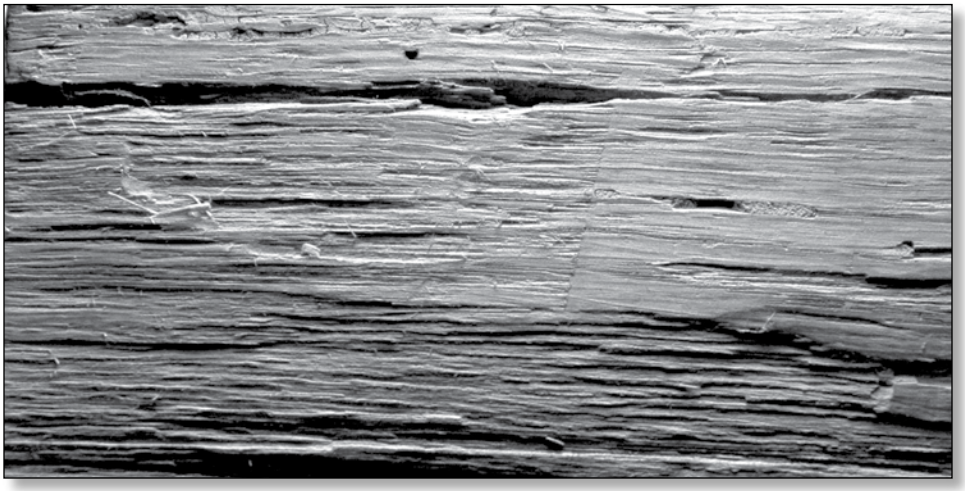
Figure 2 (right). Adze marks typically appear as omni-directional facets about the size of an adult's open hand.

Figure 3 (right). Broad axe cutting edges range in size from 6 inches to 24 inches, and slice off the surface of the timber.

Figure 4 (below). Sometimes a broad axe leaves directional facets, but the chopping marks are distinguishable.

Figure 5 (left). The froe being driven into the end grain of the log section.

Figure 6 (below). The surface of a riven board looks like a piece of split firewood.



done initially with a spud, or bark peeler, or an adze or axe (Figure 1.). An adze is an extremely sharp tool that cuts in a hoe-like fashion, as it has a cutting head perpendicular to the handle. It can be used either along the grain to smooth out the length of the stock or perpendicular to the grain to smooth up across the log rather than with the log. Adzes may be gently curved, especially the cross-grain adze, while the straight adze has a flatter cross section for the cutting edge. These tools leave very pronounced marks on the wood which are easily identified by the size of their facets (Figure 2).

An adjunct process would be to clean up surfaces with an axe, or a broad axe, whose cutting blade is parallel to the handle. These are used down the length of the board, chopping it along the plane and cleaning it up quite nicely. In some extreme instances, a broad axe could be two feet wide or more, and would require a high degree of dexterity, strength, and skill to use. A broad axe leaves very distinctive markings —similar to an adze in concept, but different in reality because the cutting surface can be so much larger and longer than from an adze (Figure 4).

These tools were not exclusive to European heritage. Illustrations from Asby Brown's book, *The Genius of Japanese Carpentry*, or William Coaldrake's *The Way of the Carpenter* show that very similar tools were employed in cultures half a world a way.

The end product from hewing is usually a large piece of wood made somewhat rectangular from the round log. At this point the piece, called a timber, is ready for further cutting to be used for furniture making, or simply left essentially "as is" for architectural post-and-beam framing or similar construction.

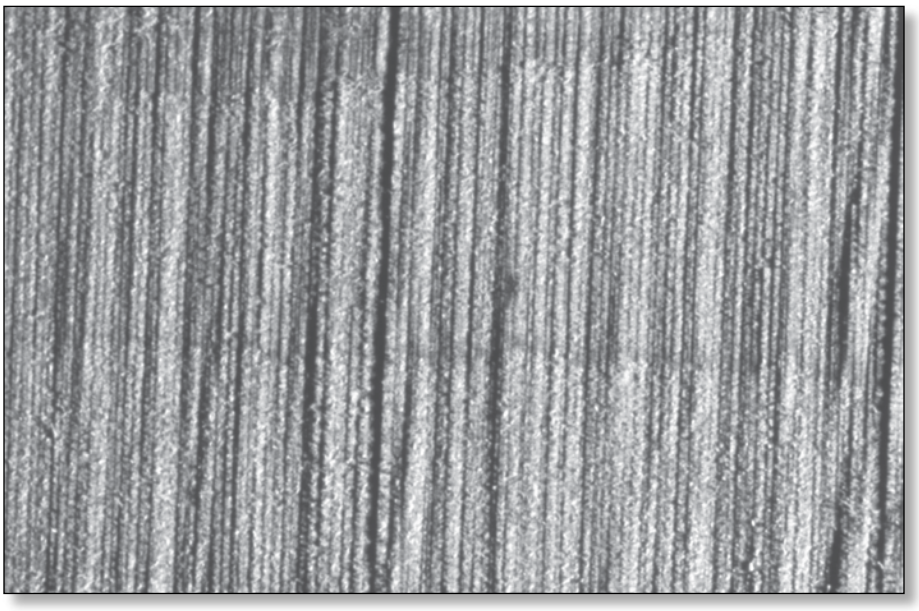
An intermediate technology between hewing and sawing is to make smaller pieces from logs by splitting them into long, tapered cross-section boards. This process is known as riving, and the resulting wood is "riven" wood. The splitting tool used is called a froe (Figure 5). It is driven into the end grain of the log with a mallet called a "beetle" to split the material along its longitudinal axis. Once the froe has been driven in, it is twisted to split the wood further. This process actually pulls the grain apart, yielding a certain shredded look on the surface of the board. Another useful thing to remember is that a board riven from a log will often be wedge shaped in cross section because it involves splitting apart a cylindrical shape, and so any segment of it is going to reflect that (Figure 6). This may be particularly noticeable on some seventeenth-century chests (or earlier) that are constructed of riven material. There is an actual, measurable taper from one side of the board to the other that is a result of reducing the cylindrical material by this means.

Sawing

One definite advantage between hewing and lumbering is that the latter could easily incorporate cutting pieces up not just cross section but also along their length with saws (Figure 7). There are many types and forms of saws dating back three millennia. It is important to make the distinction between a frame saw, whose blade was held in a rectangular frame, and an open saw (basically a blade and a handle), or even a back saw, which was not used in a frame but has instead a heavy metal spine to stiffen the blade. While they were of similar depth, that is the blades were approximately the same distance from teeth to back, the frame saw was usually narrower in cross-sectional width. Both arrangements would allow the sawyer to cut a very straight line. The process leaves unmistakable evidence in the form of the kerf mark (Figure 8). The kerf is the void in the wood from which the wood has been excavated by the saw teeth, and the marks on the shoulder of that void, or surface of the wood, are called the kerf marks or kerf chatter. Lumbering involved the sawing of very large pieces of wood or logs—big, heavy items that workmen did not want to move any more than absolutely necessary. The two main Western devices for accomplishing the task with human power were to hoist the work piece onto trestles, placing them above head height, or place the work piece over a pit (Figure 9). In the end, either arrangement usually required two sawyers operating the saw; one from above the work piece, the other from below.

Figure 7. Sawing.

Figure 8 (below). Regardless of the specific tool, hand sawing results in a kerf that looks like this; the only difference is the scale of the chatter.



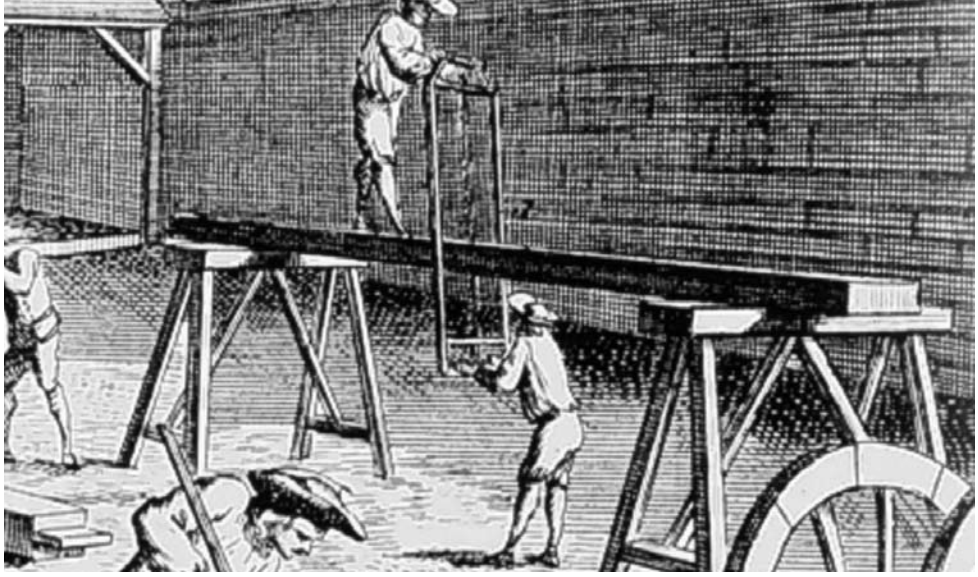
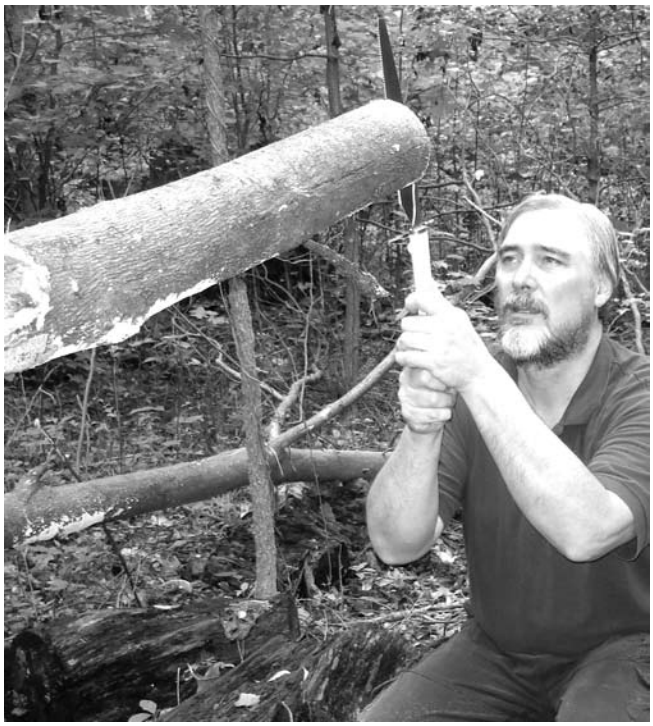


Figure 9 (left). An engraving from Diderot of an eighteenth-century trestle frame saw operation.

Figure 10 (below, left). The Oriental style of ripping timbers.

Figure 11 (below, right). An eighteenth-century "saw horse" allowing very precise work in the shop.



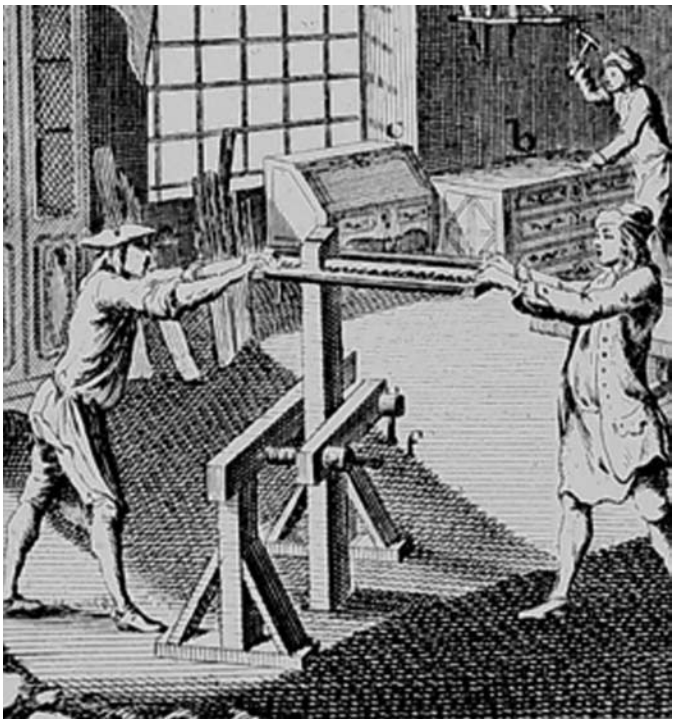


Figure 12. Sawing veneers with a bow saw.

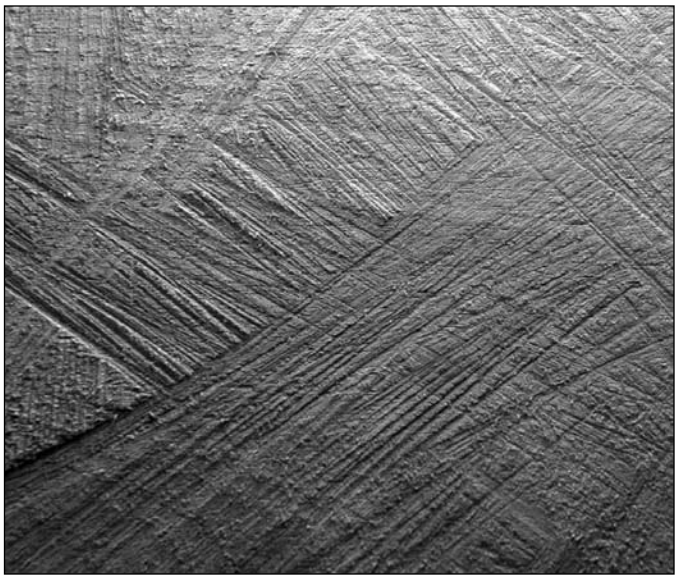


Figure 13. Note the two sets of kerf lines, each approximately 45 degrees from vertical.

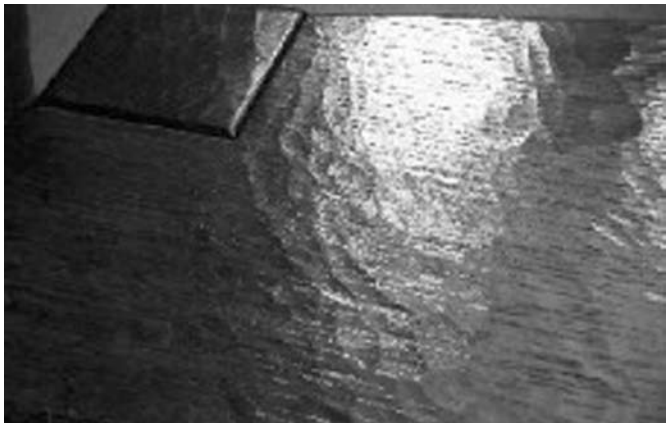
Figure 14 (left). The Japanese "spear plane."

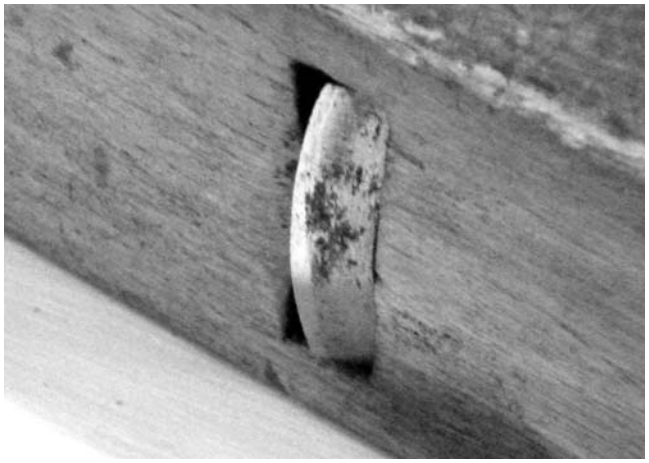
Figure 15 (below, left). The faceted surface left by the spear plane.

Figure 16 (below, top). A traditional wooden-bodied horned scrub plane.

Figure 17 (below, middle). The rounded profile of the scrub plane iron.

Figure 18 (below, bottom). A scrub plane renders a fairly flat, "guttered" surface reflecting the iron profile.





The workman on top (the "tiller") would steer and pull the saw up and then the weight of the saw plus a little assistance from the workman on the bottom would pull the saw down with great force, allowing the saw teeth to cut through the piece of wood. You might think the workman on the bottom had the easier job, which may be true in one sense—he didn't have to pull as hard as the upper sawyer—but he got showered with all the chips. So the senior, more privileged person, worked on top.

Sawing was an esteemed art of the time and something to be respected because of the value of efficiently extracting the cabinetmaker's material from a reasonably scarce, difficult-to-obtain source. There were lengthy contemporary historical treatises on the subject, perhaps none more compulsive than a complete French encyclopedia dedicated to the topic. This distinction became even more pronounced with the advent of exotic woods imported from the tropics.

Again, halfway around the world, Japanese craftsmen were doing essentially the same thing, though they were often holding up one end of the board onto a single A-frame trestle, sitting underneath with a saw held overhead, and working their way down a gently sloping timber rather than holding the whole log up on trestles or putting it over a pit (Figure 10). This strikes me as the worst of all possible situations. The single

Figure 19 (above,). The iron of the traditional toothing plane is nearly perpendicular to the work surface.

Figure 20 (below). Nothing else looks like the micro-grooved surface left behind by the toothing plane.

sawyer not only had to do the steering and provide the motive power, he got to eat all the wood chips as well.

One adaptation of the earlier Western method was to take smaller pieces and hold them vertically and saw them in the workshop (Figure 11). This worked for small pieces of wood or even the cutting of veneers. Imagine the precision required to cut pieces of veneer one or two millimeters thick, dozens and dozens times in a row (Figures 12–13).

Surface Preparation

The next step in creating usable lumber for joinery or other furnituremaking would have been to remove as many of these hewing or sawing marks as possible by using planes. A plane is simply a sharpened piece of iron or steel held in a jig that, when run over the surface of the wood, shaves off very thin pieces. At the initial stages of smoothing, in the West, artisans employed scrub planes, while in the Orient, they used the spear chisel, or planing chisel, which cuts along an edge much as a broad axe or adze (Figure 14). It was used in a sweeping, scything motion across the surface of the workplace to remove the cutting marks (Figure 15).

A well-tuned plane skillfully used will remove gossamer strips one after another from the surface. Planes themselves leave marks. Both Eastern and Western planes have various contours. Some of them, such as the relatively coarse scrub plane, are slightly rounded to aid in the rapid removal of material (Figures 16 and 17). Often the bottoms of seventeenth- and eighteenth-century drawers display the characteristic "washboard" marks, which are very common when the craftsmen did not bother to clean up the workpiece further (Figure 18). The craftsmen got it more or less planar and left it that way.

Another stock preparation plane was the toothing plane, whose primary value is that it can aggressively cut down wildly figured grain planks without causing undo amounts of snagging or "tearing out" (Figure 19). Toothing planes leave marks akin to a comb being dragged along the surface of the wood,

Figure 21 (right). Craftsmen have a wide range of planes, each leaving similar but distinctive marks.

Figure 22 (below, left). A beautifully hand-planed surface has a slight undulating surface.

Figure 23 (below, right). Knife cut layout lines for a handmade dovetail joint.

and for that reason were used primarily for undersides or most especially the undersides of veneers and the gluing surfaces on the carcass (Figure 20).

Finally, the surfaces would be finished with bench planes and scrapers, leaving a magnificent surface that was a feast for the eyes and a treat to the fingers (Figures 21 and 22). Planes generally leave long marks showing the gouged-out materials and the edges of the plane irons themselves. Again this evidence of the process was nearly identical in East and West even though the tools and techniques were different.

Laying out the joinery was accomplished with cutting scribes or ink marks, and these are the sure sign that a joint was hand cut (Figure 23). Some of the tools were different, but conceptually the process was identical. This may be very intricate and precise work, as it was integral to accurate "laying out" or marking the cut for assembly of the various pieces.

Mechanical Processes

Distinguishing between hand processes and pre-robotic mechanical processes depends almost entirely on your ability to distinguish between an irregular surface and a regular surface. The human body is capable of a nearly infinite range of motions which are controlled to a greater or lesser degree by practice, skill, and health. Even highly skilled artisans do not make perfect things. Perfectly lovely things, to be sure. But not perfect. As such, the evidence of a human fashioning an artifact is irregularities.

Figure 24 (left, top). A water-powered, up-and-down saw mill in the collection of the Smithsonian's National Museum of American History.

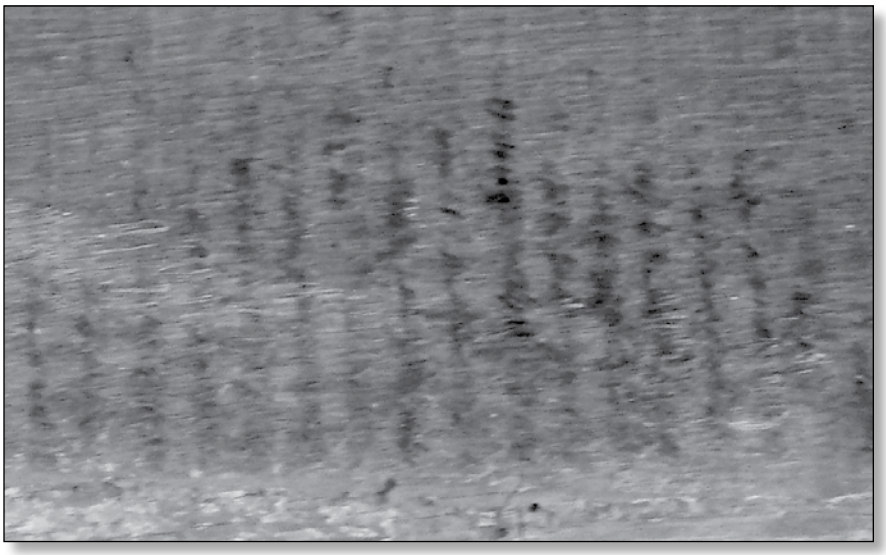


Figure 25 (left). The ratcheting function of the sled coordinated with the up and down action of the blade renders a perfectly regular set of chatter marks.

On the other hand, in a pre-robotic world machines and mechanical devices can only do two things. They can go back and forth, or they can go round and round. That's it. Every task they accomplish is some combination of these. So for mechanically fashioned objects, we are looking for regularity of tool marks—perfect, metronomic regularity.

When we have hands steering the machines, we get a combination of regularity and irregularity.

Sawing

The industrial, or mechanical, process of lumbering begins perhaps as early as the fifteenth-century with water-driven, up-and-down saws (Figure 24). Think of the frame saw, attached to an armature going to the waterwheel, the cam action of the rotating wheel pulling the blade up and down. The actual sawing motion is powered by the waterwheel. The real added benefit was that the whole log was "dogged in" or mounted on a sled that could be mechanically pulled through the blade. Rather than moving the blade through the workpiece, the workpiece was pulled through the sawblade. The tool mark would be a very regular up-and-down cut with a ratcheting effect from the water-powered devices pulling it through the blade (Figure 25). The next big step in historical technology in the late-eighteenth century was the circular saw, which has a blade with sharpened teeth mounted to a disc that rotated (Figure 26). The workpiece comes into it, and the sharpened teeth cut through the piece. There are still scores, if not hundreds, of local, large-scale (forty-eight to sixty inches) circular sawmills operating today. I use a sawmill, not twenty miles from my house, run by an Amish family who has a circular blade hooked up to a diesel engine. It's a horrifying and frightening experience to watch a five-foot diameter blade cut through logs, but under the control of an experienced sawyer

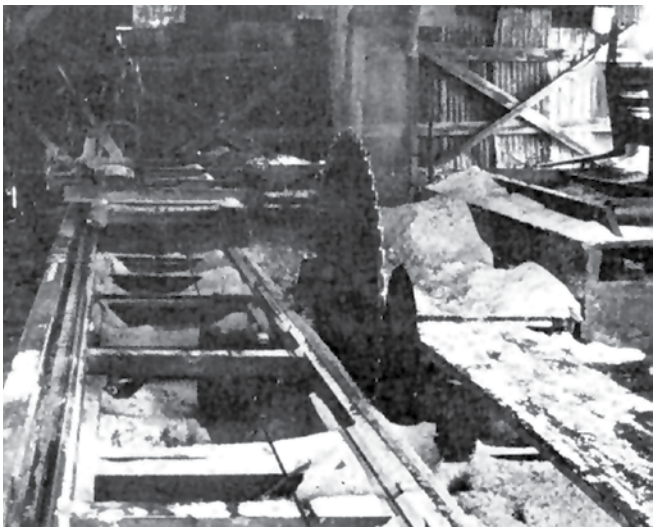
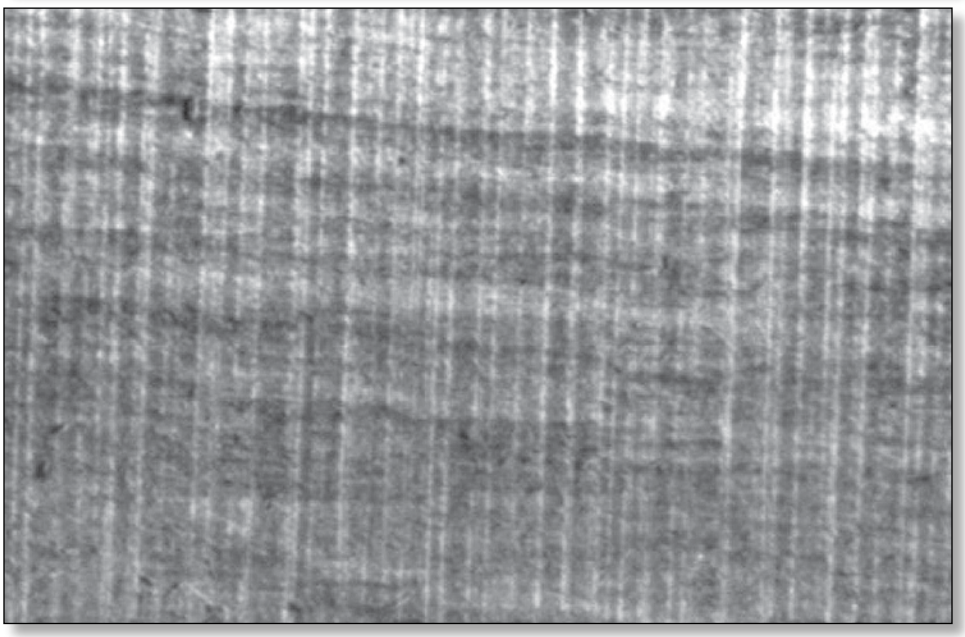


Figure 26 (left). A large-format circular saw mill.

Figure 27 (below, left). The arcing kerf chatter of the circular saw.

Figure 28 (below, right). Band saw marks are fairly regular and always exactly perpendicular to workpiece.



it does result in boards of the dimensions you want. In addition, smaller circular saws are the workhorse of modern woodworking, in virtually every professional and hobbyist's woodworking shop in the Western world. These saws are used for both cutting long-wise ("ripping") or cutting boards to length ("cross cutting"). Regardless, the circular saw leaves a kerf with very distinctive arcing cut marks that exactly correspond to the dimensions of the blade itself (Figure 27).

Another relatively contemporary tool is the band saw, which came into industrial usage in the mid-nineteenth century. A band saw is a continuous steel band, with teeth on one or both sides, depending on how large and sophisticated it is (Figure 28). The band saw blade is in continuous motion as the blade runs around the power-driven wheels, through which you run the boards. The marks of a band saw are basically perpendicular, but there is a certain irregularity to the pattern (unless it is a power-feed machine, which is not common in craft shops; it is more common in mills). Because a band is under tension, there is a vibration or "chatter" to the band itself, and the marks are somewhat more irregular than those of the water-powered up-and-down saw.

A recent development is the use of a chainsaw with an attachment. You can do chainsaw timbering, whereby this is really a jig holding the cutting

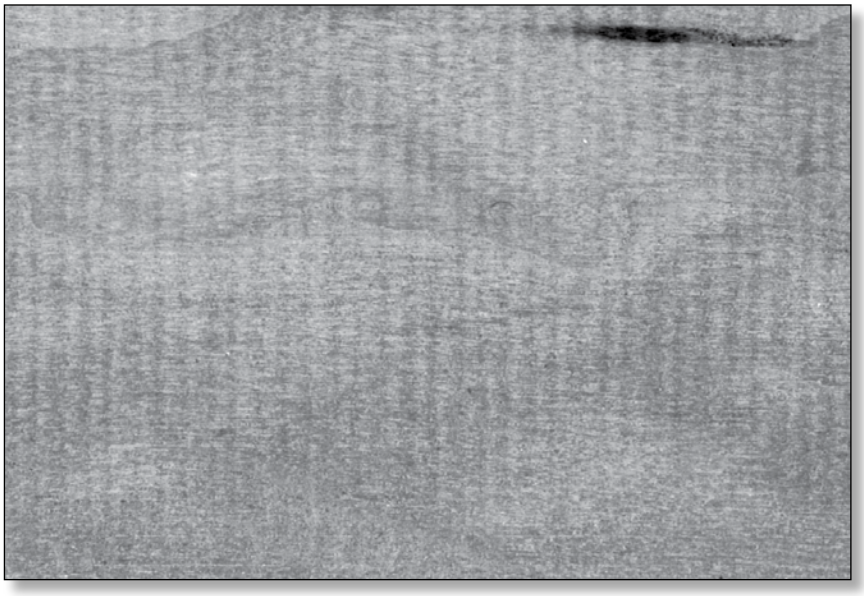


Figure 29 (left). Power planers and joiners leave shadowy indentations and undulations.

Figure 30 (left, center). The metal scraper is the simplest possible tool that has changed little in several centuries.

Figure 31 (left, bottom). The scraped surface —unique in being nearly devoid of tool marks —is a feast for the senses

surface at a fixed distance to the top surface, so you can slice off boards in a way that is not unlike slicing cheese. The marks of a chainsaw are extremely coarse and irregular.

Surfacing

A jointer/planer is a modern tool that has replaced a hand plane in many circumstances. Sometimes referred to separately as a jointer and a planer, they are in fact the same tool; one is simply the upside-down version of the other. It has a cylindrical cutting head with knives attached to it, and this is rotating and scalloping off material. The business portion of a jointer/planer has exactly the same conceptual function as an adze, but it is more controlled and precise. Again, as with the adze, this scalloping leaves its own marks. These marks are shadowy and perpendicular to the grain, and are evident on wood that has been processed in this manner (Figure 29). At a later point if the craftsmen wanted to lose these marks, which they normally do, the workpiece would be very lightly planed by hand with a smoothing plane or scraped with a scraper (Figures 30 and 31).

Alternately in this post-craftsmanship age, the surface would be prepared through various grinding machines called sanders. The main two types are belt sanders, which leave parallel linear gouges in the surface, and orbital sanders, who leave scores of tiny concentric circular marks (Figures 32 and 33).

Figure 32 (above). Compared to the scraper, belt sanding leaves a coarser, abraded surface.

Figure 33 (below,). Orbital sander marks.

Veneer/Plywood

Veneering is a way of removing very thin pieces of lumber from a log or other large piece of stock. The wood is either cut with a saw, as mentioned earlier, or more commonly sliced with knives. (The latter is done either by moving the knife against the workpiece or the workpiece against the knives.) Today they are using slicers where they can basically unroll a log like a roll of paper towels. It is a very highly developed and sophisticated technology called "rotary peeling." The results are often plywood and plywood-type materials, which may be fundamentally different materials than a planed board or sawn veneer.

In looking at artifacts, there are many things to think about regarding technology and various tool marks. One of the most important is knowing exactly where a piece of wood came from and how it was cut out of the log. These facts not only have great impact on the wood's visual properties (tangential sawn wood looks very different from radially sawn wood) but can provide vital clues to the history of the artifact and the materials from which it is made.

If you have an object reputed to be circa 1840, but an examination of it revealed that all of the veneers were rotary-peeled, knife-cut veneers held in place by neoprene adhesive, you had best rethink someone's presuppositions. It might have been circa 1840 at one time, but now must be considered a contemporary thing. In other instances, items reputed to be from the 1690s had integral elements made of plywood, evident immediately to the skillful eye but unnoticed by the unskilled one, suggesting a date more akin to the 1960s, not the 1690s.

Conclusion

Surfaces can impart a tremendous amount of important information about how an artifact actually came to be and in some cases, what has happened to it since that time. Once you learn to look, where to look, and what to look for, you will be amazed at what a piece of furniture has to tell you.

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