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Bill Krier
Editor in Chief, WOOD magazine

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# Bent Lamination

## Create curved project parts the easy way with strips of wood, glue, and a form

**We all know that curves are pleasing to the eye. The question for woodworkers is: What's the best way to make them? In some cases, you can cut an arching shape from a solid piece of stock. Or you can build up a blank with mitered pieces, and then cut it into a curve. But more often it's best to bend wood to get the shape you want. Why? Because bending usually produces a stronger, better-looking result and wastes much less wood.**

## Gather your materials

Consider wood species, thickness, and width as you plan your lamination. We used quartersawn white oak for our rockers; see "The straight skinny on bending" at the end of this article for a general guide to the bending properties of white oak and several other commonly used woods. If you plan to use a wood not listed in the chart, try this test. First, cut a sample strip to width and thickness. Then, bandsaw a particleboard form to the needed radius, and bend the sample strip around it.

To make the gentle curve required for rockers, we resawed a board into strips ¼" thick and 3¾" wide. Those dimensions worked great, but a sharper bend would have called for thinner stock, and greater width could have created problems in the form of surface cracks or complete breaks.

Within any species, some boards are better bending candidates than others. Reject any board with knots or wavy grain. Select boards with straight grain on the edges *and* faces. In **Photo A**, you see two very different ash samples.

We recommend standard yellow glue for lamination bending. The "Extend" versions of Franklin's Titebond glues give you more time to assemble your lamination and adjust the clamps. For outdoor projects, use water-resistant Type II yellow glue or polyurethane. (See "Do you need a heavy-duty adhesive?" on *page 7* for information about other choices.)

Particleboard works well for making your bending forms. It's easily shaped and inexpensive. You also can choose plywood. Finally, be sure to have plenty of clamps on hand. Sliding bar clamps are the most convenient choice for the job, and provide adequate clamping pressure.


**Look for bending stock with straight grain, like that on the right. When grain runs in various directions, as on the left, it's quite likely to break.**

## Build your form

To end up with a perfect curve, start with a perfect form. Use a plan pattern, trace an existing piece, or use a trammel to make a radius. We laid out our rockers with a 48" trammel, a pencil, and a piece of particleboard.

Cut the sheet stock just larger than the shape you've drawn. Now, cut more pieces to the same dimensions, until you have enough to laminate a form that's approximately equal in thickness to the width of your bending stock. Use your bandsaw to cut about ⅛" outside of the line you marked on the first piece, and then sand to the line. Use this template to mark the rest of the pieces, and bandsaw them ⅛" outside of their lines.

Now, use yellow glue and screws to begin building the form. Add one piece at a time, and trim each piece to match the previous one with a flush-trim bit in your router, as shown in **Photo B**.

After completing the form, apply packaging tape to the bending surface, as shown in **Photo C**. The tape will keep your glued-up lamination from sticking to the form.

## Cut the laminations

Slice thin strips of wood from standard lumber, using either the tablesaw or the bandsaw. (The chart at the end of this article gives you thickness recommendations.) Thinner strips produce a bend that holds its shape better. Thicker strips tend to spring back somewhat after you remove the clamps, slightly flattening the curve. We got a springback of about ⅜" on our chair rockers, as measured at the center of the arch. Make your laminate strips ¼" wider than the completed piece, so you can trim away any roughness after the glue-up dries. Also make them 2" longer than the completed piece to allow for accurate trimming to final length.

A well-tuned bandsaw can handle most resawing tasks. However,


**Particleboard serves well as material for bending forms because it's inexpensive, easily milled, and free of voids. Use enough sheets to equal or exceed the width of your laminate strips.**


**Any kind of tape will keep glue off your forms; this clear packaging tape is wide and easy to remove when you're done.**

if you need lamination strips less than 6" in width, you might find it easier to cut them on the tablesaw, using a 24-tooth rip blade. For most of us, the tablesaw produces smoother, straighter surfaces than the bandsaw, although it wastes more stock by cutting a wider kerf.

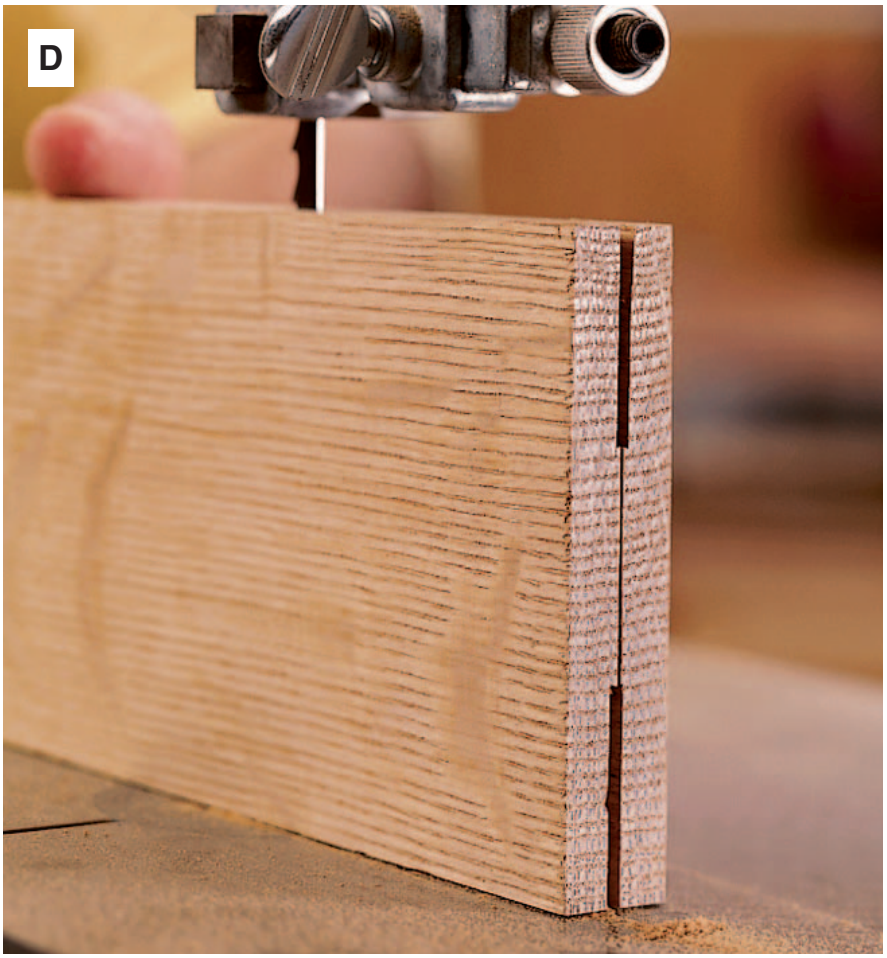
See **Photo D** for another good resawing option. Run the original workpiece across your jointer after each cut so you always have one perfectly smooth surface. Scrape, plane, or sand the other surfaces smooth. Cut one extra strip to serve as a clamping surface.

Test a sample strip on your form before you cut the whole stack. You should be able to bend it to its finished shape with moderate hand pressure. When you apply glue, the wood will soak up moisture, and become even more pliable.

## Ready, set, glue

Make a dry run before you open the glue bottle. First, put your form in a position that will allow convenient clamping. If your clamps will sit vertically, as in our example, you may need to set the form on supports to make room for the clamp jaws. (Our clamping blocks took care of the problem, as you'll see shortly.) Place the stack of strips on the form, and then add as many clamps as it takes to close all gaps, with a scrap of wood under each clamp head to protect the workpiece and spread the clamping force.

Vacuum or wipe the dust from the laminate strips, and prepare to work quickly. Apply glue to both sides of each laminate joint, building the stack as you go. (Don't apply glue to the outside surfaces of the first and last pieces, or the strip that bears the clamps.) Place the stack on the form. All of that glue makes for a slippery structure, so use a clamp across the strips to hold them in position as shown in **Photo E**. Then set a clamp in the middle of the assembly, also shown, and tighten.



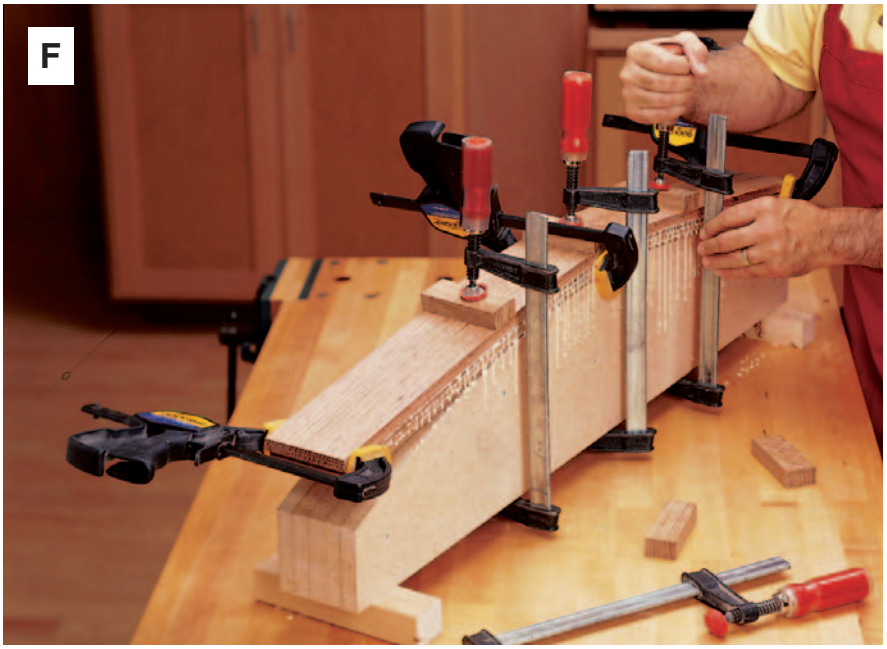

**Before resawing wide stock with a bandsaw, try cutting a kerf on both edges with the tablesaw. The bandsaw blade will tend to follow the kerfs.**


**With wide, fixed jaw faces, Quick-Grip clamps do a good job of holding the strips in alignment. Place your first bending clamp right in the middle.**

Work outward from the middle toward the ends, spacing your clamps at regular intervals, as shown in **Photos F** and **G**. When we approached the ends of the form, we attached blocks to the bottom with screws, to compensate for the clamps' tendency to slide.

Check carefully for open spots in your glue-up, and tighten or reposition your clamps as necessary. Once everything is set, clean up as much of the glue squeeze-out as possible with a putty knife, as shown in **Photo H**.

Leave the clamps in place for at least 48 hours. You want a solid, cured glue-up to guard against any movement along the joints.




**Place a block under each clamp to spread the force. Screw a block on the bottom of the form at each end to keep the final clamps from sliding.**


**Use two clamps at each end, where the bending distance and resistance are greatest. Tighten one clamp, slide the other down, tighten, and repeat.**


**Scrape off the squeeze-out before the glue hardens completely. Also, it's good shop practice to clean your forms before storing them for future use.**


**Smooth the edges of a bent lamination on your jointer. Make a test pass with the machine turned off to make sure you won't struggle with the safety guard.**


**When cutting a bent lamination on the bandsaw, keep the workpiece firmly against the table at the point where the blade enters the wood.**

## Final machining

Remove the clamps, take the bent lamination off the form, and clean up any rough spots. You could use a hand scraper or sandpaper, but a pass across the jointer, as shown in **Photo I**, quickly and easily smooths a long, gentle curve, such as our rocker.

We built our bent lamination slightly more than twice as wide as a finished rocker part. That not only saved time, by doing the work of two lamination bends in one operation, but also ensured that the two rockers are nearly identical in appearance and characteristics. If one springs back slightly, the other one should move about the same amount and remain matched. This approach works for other matching parts, too.

We ripped the completed lamination on the bandsaw, as shown in **Photo J**, to get two identical pieces. After jointing one edge on each piece, we took them down to finished width with the planer. Finally, we cut them to length on the bandsaw, and proceeded to fit them to our chair.

Produced by **Marlen Kemmet**
Written by **Jim Pollock** with **Charles I. Hedlund**
Graphic Design: **Jamie Downing**
Photographs: **Marty Baldwin**

## What to know before you try multiple curves

Here's how we used mating forms to make the sinuous legs for a bentwood accent.

It's difficult to get good results from a single form when you build a piece with multiple curves. In those situations, press the lamination strips between two or more mating forms.

Here's the key to making mating forms: Remember that they won't match up correctly if you simply bandsaw them apart, and then place several lamination strips in between. When you cut your form stock into mating pieces, you need to remove a band of material equal in width to the thickness of your planned lamination.

### Do you need a heavy-duty adhesive?

Some experts recommend using plastic resin glue, modified urea formaldehyde glue, or epoxy for lamination bending, pointing out that those adhesives dry rock-hard, while yellow glue remains slightly soft. We opt for yellow glue because it's much more convenient to use, and, in our experience, "creep" along the glue lines never has presented a problem.

If you build a curve that will be subject to unusual stress will have to withstand a great deal of outdoor moisture, consider the harder glues. However, remember that plastic resin glue and modified urea formaldehyde are toxic. Wear gloves and a dust mask when mixing the powders, and put on the mask again when you sand hardened squeeze-out. Also, epoxy generates heat when mixed, and overexposure can lead to serious skin reactions.

# The straight skinny on bending

We tested the bending properties of seven types of wood, with each sample measuring ¾" wide and featuring straight grain. Here you see the results of three different thicknesses and five radii. For each bend, the species shown in black made the grade, but the ones in red cracked or snapped in two.

**radius of form**

| thickness of wood | 16" | 12" | 8" | 4" | 2" |
|---|---|---|---|---|---|
| 1/4" | ash, cherry, mahogany, pine, red oak, white oak, cedar | ash, cherry, mahogany, pine, red oak, white oak | ash, pine, cherry, mahogany, red oak, white oak | ash, pine | |
| 1/8" | ash, cedar, cherry, mahogany, pine, red oak, white oak | ash, cedar, cherry, mahogany, pine, red oak, white oak | ash, cedar, cherry, mahogany, pine, red oak, white oak | ash, mahogany, pine, red oak, cedar, cherry, white oak | ash, mahogany, pine, red oak |
| 1/16" | ash, cedar, cherry, mahogany, pine, red oak, white oak | ash, cedar, cherry, mahogany, pine, red oak, white oak | ash, cedar, cherry, mahogany, pine, red oak, white oak | ash, cedar, cherry, mahogany, pine, red oak, white oak | ash, cedar, mahogany, pine, red oak, cherry, white oak |


**For bends as sharp as this 2" radius, plan on using strips no thicker than 1/16". Most of our samples made the grade.**


**When cut to ¼", this piece of cedar couldn't pass our easiest challenge. It splintered on a radius of 16".**

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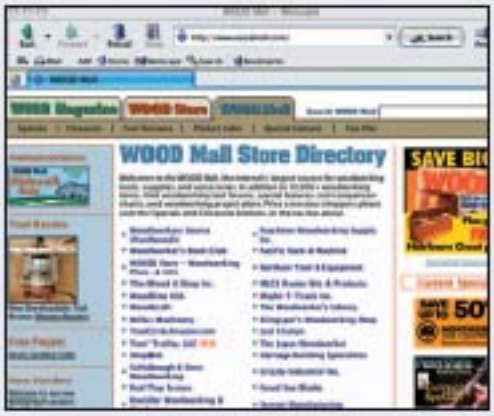


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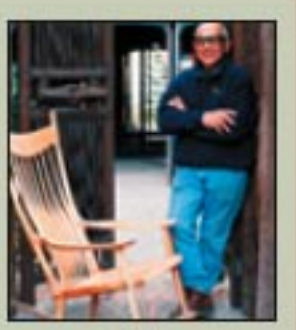
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