Tapered Lamination

Slender curves have necessary bulk for joinery

by Jere Osgood

Thin layers of wood are easy to bend. Several thin layers, all with the grain running in the same direction, can be bent on a form and glued together. The resulting curved laminate is much stronger than a piece sawn from solid stock would be, and much less wasteful of material. It is also stronger than a steam-bent piece, because the glue adds to the strength of the wood. Lamination has the additional advantage of stretching rare or highly figured boards, since the best stock can be resawn and used to face all the legs of a chair or table.

I discussed the basics of simple bent lamination, the necessary forms and the gluing techniques in the Spring '77 issue of *Fine Woodworking* (pp. 35-38). This article will cover layers of wood that are not of uniform thickness—tapered laminations and double tapered laminations. These techniques permit you to make a curved piece whose width and thickness vary, whereas a simple bent lamination can vary only in width. If the design requires cutting through the thickness of a layer of wood at any point along a curve, the whole part is weakened. The severed layers no longer contribute to the strength of the assembly. The problem is avoided by tapering the layers of wood, so the variation in thickness is built right into the lamination. It is important to make each layer of wood as thick as possible although still thin enough to follow the desired curve. It is much better to resaw stock to optimum thickness than to use many layers of thin veneer.

I know that my methods are liable to appear fussy or confusing to people who are accustomed to bandsawing curves from heavy, solid stock, but they will appeal to assemblers and people who enjoy complicated joinery. I prefer to spend time on the planning and drawing, instead of on carving huge amounts of waste from unformed heavy stock. Once a curve has been laminated, it is hard to alter the outward shape. It is simple to revise the shape of a bandsawn part. Because accurate previsualization comes with experience, I don't find being locked in a disadvantage. When I teach, I mention many times the absolute necessity of making full-size shop drawings. Many part-time woodworkers don't do this, but it is the key to seeing the shape of the finished, three-dimensional object. And it is the only way to be sure from the start that the joinery is possible.

This method of working has also been criticized as less than true to the material. Obviously I don't agree, and I don't think the things I make are any less woodlike than more traditional construction. If anything, a simple chest with curved sides and a bow front (obtainable by the compound staved lamination system, the subject of a future article) is much more like a curving tree than is a chest with flat board sides, carved to represent folded linen. Although I make contemporary furniture, I should add that this method has nothing to do with style or design. Tapered laminates can make a traditionally curved leg, and compound staved laminates could be put to good use in producing a French bombe chest.

Tapered lamination Once you have made a shop drawing—for example of a table—and decided that a tapered lamination would make the strongest leg, you need to figure the measurements of the thickness-planer jig that will produce the necessary laminates. From the shop drawing, you need to know the thickness of the curved leg at both ends, and the length of the curve if it were straightened out.

To find the length, draw a center line on the curved part. Set a pair of dividers at an inch or less and walk the dividers down the center line. To decide the number and thickness of the layers of wood, look first at the small end of the leg. Suppose it is 1 in. thick—eight layers, each ⅛ in. thick, would be

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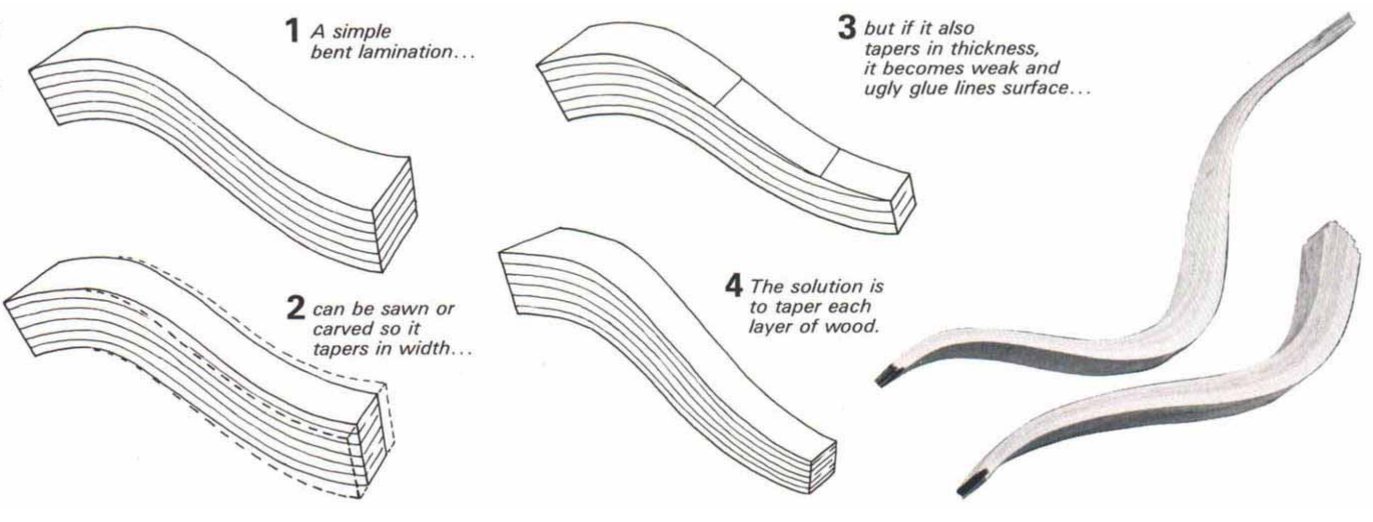
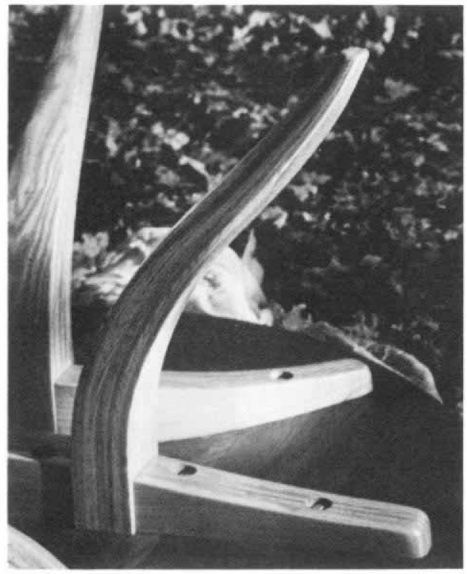
Illustrations: Christopher Clapp





Ash legs of table are single-tapered lamination. Table top is teak, and measures 57 in. diameter. Table is 29 in. high.

convenient. Now look at the thick end, perhaps 2½ in. thick, and divide by eight to get 5⁄16 in. Bear in mind here that the thin layers must turn the curve you have drawn, both at the thin end and at the thick end. There are no rules, but a little experience will give you a feel for the bending radii of different woods of various thicknesses.

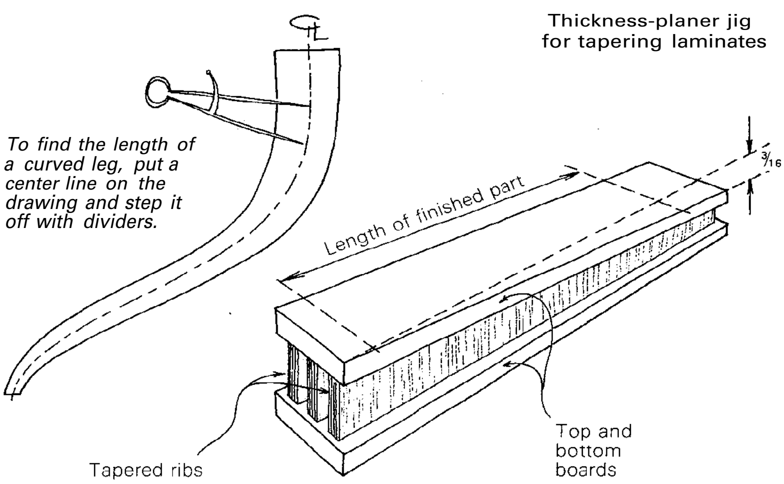
The thickness-planer jig is a sloping platform that carries the stock through the machine. It should be a few inches longer than the finished length of the stock, and the laminates should be cut to the same oversize length. If each laminate is to taper from ⅛ in. at one end to 5⁄16 in. at the other, the slope of the jig has to express the difference, or 3⁄16 in.

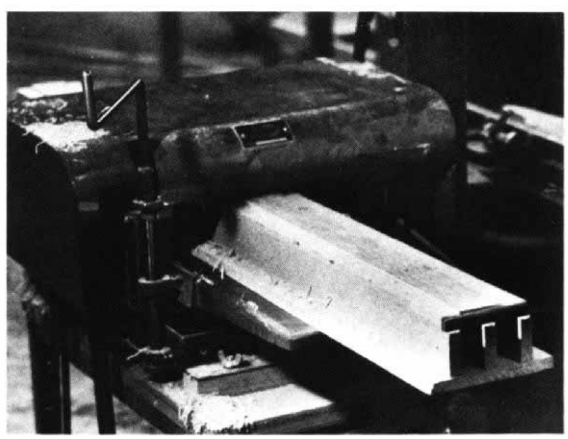
The most accurate way to make a thicknesser jig is with top and bottom boards of some sort of plywood and several central ribs of plywood or particle board running the length of the jig. Since the support ribs are all exactly the same, I would nail or tape them together and carefully cut them as a package on the band saw or with a table-saw taper jig. Spread the ribs out on the base and glue them down, then glue on the top board. It might seem easier merely to sandwich a 3⁄16-in. wedge between two boards, but it isn't. The boards would deflect under the pressure of the planer's feed rolls and create a hump on the finished leg. Remember, each little error in the thicknesser jig multiplies by the number of layers in the lamination. Saw the stock for the laminates thicker than the thick end of the taper, and plane it smooth on one side before tapering in the thicknesser. This ensures uniform pieces. Feed the thinner end of the jig into the machine first, and you'll find that it doesn't require a stop block—the feed pressure against the taper will easily hold the laminates in place.

If you plan to use a one-part, open-face gluing form, the form line can probably be taken directly from your original shop drawing. Remember, though, to face the form with several layers of hardboard and to use more hardboard between the clamps and the laminates to even out the pressure. Account for the thickness of the hardboard in your layout. I'll return to forms later, after giving layout directions for a two-part form, which provides the most even pressure in gluing.

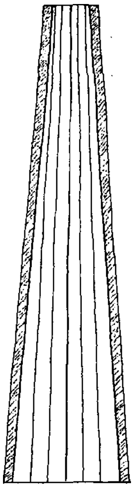
After the laminates are made, clamp them into a package that includes a piece of ¼-in. hardboard (or two ⅛-in. layers) on each side as a form liner. Trace the outline of the whole package onto a piece of drawing paper, or be more precise by measuring the thickness of the ends with calipers and transferring the size to the paper. Now draw in a center line and cross it with uniformly spaced perpendicular sections. I usually make them an inch apart and number them.

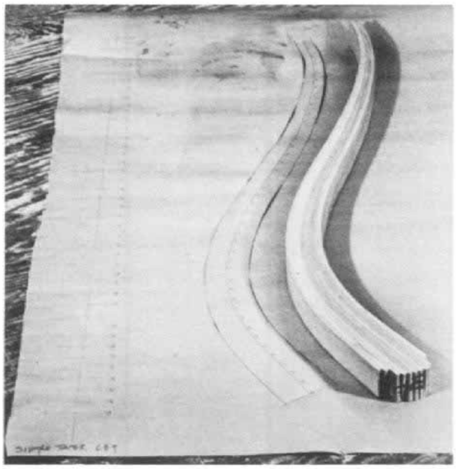
From the full-size shop drawing, transfer the center line of the curved part onto a heavy piece of drawing paper. If you



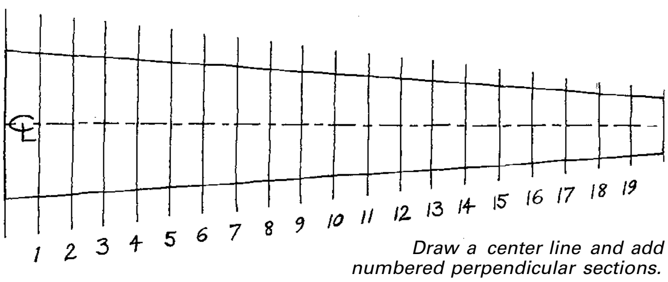


Thin end of jig is fed into planer first—pressure holds laminates in place, and no stop block is required.

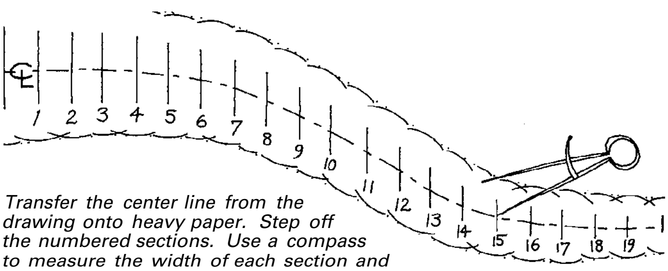




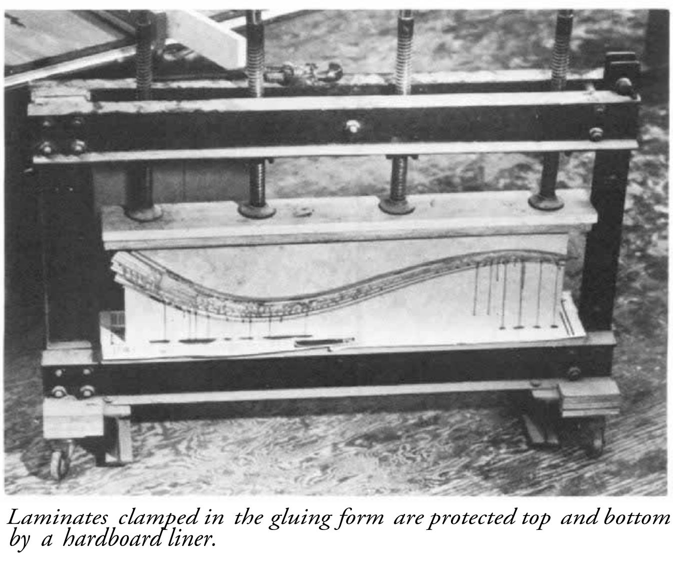
To lay out a two-part gluing form, clamp the hardboard facings and the tapered laminate into a package and trace its outline.



Draw a center line and add numbered perpendicular sections.



Transfer the center line from the drawing onto heavy paper. Step off the numbered sections. Use a compass to measure the width of each section and swing arcs at the corresponding marks along the curved line. Connect the crests and this is your pattern.



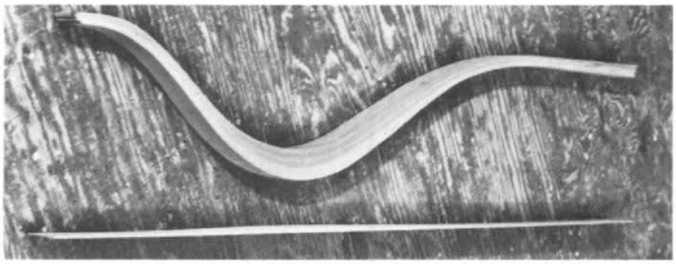
Laminates clamped in the gluing form are protected top and bottom by a hardboard liner.

anticipate a problem with springback, now is the time to consider it: Bend the center line a little farther at each end to compensate. Now on the center line walk off with dividers the same spacing you used for the perpendiculars on the flat package, and transfer the numbers too. With a compass, transfer the width at each numbered section, one section at a time, and swing arcs on both sides of the center line. The radius of each arc is the distance from the center line to the edge of the package of laminates, plus the layers of hardboard. When all the arcs are drawn, connect their crests with a flexible curve or a thin, springy piece of wood. This now is the pattern for the gluing form. For a narrow part such as a chair or table leg, I would bandsaw the form itself from a solid block glued up of several layers of chipboard or plywood. After gluing, check the finished leg against the shop drawing. If there is any difference, alter the drawing to conform, as this slight change might alter the measurements and the joinery of the piece of furniture you are making.

Double-tapered lamination A double-tapered lamination is often used for chair legs, where lightness is required along a delicate curve that might reflect the shapes of the human body. The curve still must be very strong, and the part must thicken at the joints. For example, the back leg of a chair might be of one thickness where it touches the floor, another at the seat rail, and a third thickness at the top. The laminates have to bend easily to the curve and must not have an odd thinness at one end. The initial calculations might yield laminates 1/8 in. thick at one end, 1/4 in. at the middle, but only 1/32 in. at the other end. This would be too fragile to machine, and you would have to decrease the number of laminates. This would make them thicker, perhaps too thick to turn the radius—you must revise the design.

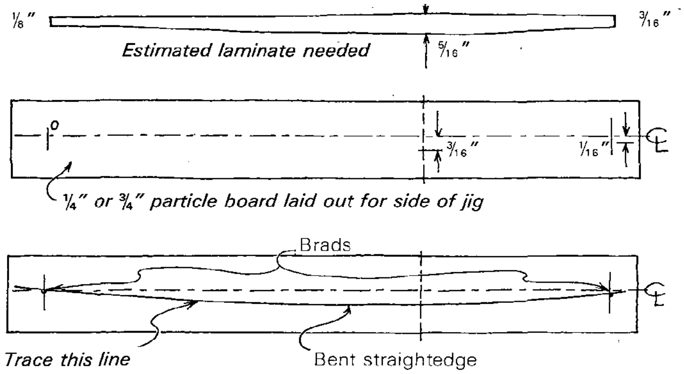
For the sake of the discussion, suppose you arrive at a laminate that is 1/8 in. thick at the top end, 5/16 in. at its thickest point and 3/16 in. at the bottom. Use dividers to take the overall length of the curved piece from the shop drawing, as before. This will also locate the thickest point along its length. Now you can make a thickness-planer jig as before, except its top surface will be curved. The machine's feed rolls force the stock against the curve and the resulting laminate will taper uniformly from thin to thick and back to thin. To do it, start with a piece of plywood or particle board that is 3 in. overlong and perhaps 3 in. wide. Draw a center line. Subtract the thickness of the laminate at the small end from the thickness limits. The 1/8 in. becomes zero, and the other two differences represent deflection from the center line along the length—in this example, 3/16 in. and 1/16 in. Mark these points along the center line. Put a brad into the particle board on the center line at one end, and another 1/16 in. down from the line at the other end. Set a good steel or wood straightedge on the brads, and push it down to the 3/16-in. mark at the thickest point. Draw a line carefully along the bent straightedge. Now bandsaw several rib supports along this line (in a package, as before) and glue them to a base board. Face the top of the form with a couple of layers of hardboard, glued together and glued to the ribs.

With the stock planed on one side and in place, feed the thin end into the planer, as before. Unlike a single taper, where planing downhill makes tearout unlikely, a double taper sometimes shreds. Therefore cut extra stock before you start to plane, and carefully check the grain direction of each



Double-tapered lamination (top) and one of its components.

To lay out ribs for double taperjig, measure the necessary deflection from a center line and connect the points with a bent straightedge.



piece. If the grain tears out on the first pass, try reversing it on the jig. It may seem like a good idea to make the jig and the stock wide enough for several legs to be sawn out of a wide laminate. This usually doesn't work—tearout becomes a more serious problem, and inaccuracies in side-to-side thickness creep in.

It is usually better to glue up a double taper on a one-part form, facing both sides with hardboard and using as many quick-set clamps as will fit along the curve. A two-part form would give more uniform pressure, but the complications of making and testing may not be worth the effort.

Notes on laminating Press forms can be made of particle board, plywood or any sturdy material that can be sawn evenly. Form stock is better if it has no strong grain for the band-saw blade to track off into—construction fir is unsuitable. Forms are difficult to sand or rasp clean without introducing error. It is better to use them straight from the saw.

When making forms, you can save material by spacing the parts. For example, three ½-in. layers of particle board could be spaced out to 3 in. with two ¾-in. spacers. But be sure you don't weaken the form so much that it might break in the clamps or the press.

Forms must be lined with a hardboard-type material (Masonite is one brand name), and the thickness of the liners must be accounted for in layout. You can use ¼-in. hard-

Double-tapered laminates are clamped to a one-piece form.

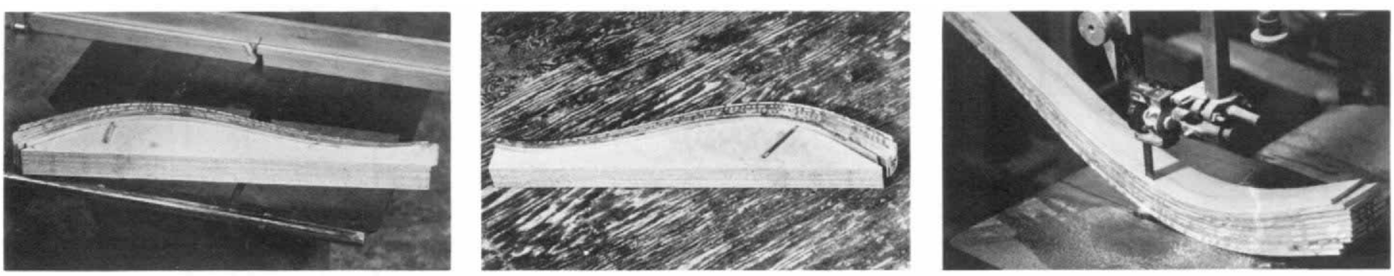
board, or several layers ⅛ in. thick, tempered or untempered, depending on the tightness of the curve. Thin plywoods are not suitable because they have a grain direction (due to the uneven number of plies and the wood itself) that interferes with bending to a particular curve.

A two-part gluing form must be precisely cut or it is not worth the bother. If the curve is difficult or the taper becomes a complicating factor, use a one-part open-face form with several layers of hardboard to distribute the clamping pressure. Attempts to pad out forms with layers of rubber, felt or cork don't work, although small discrepancies can be repaired with two or three layers of brown paper or newspaper.

Forms and hardboard facings should be waxed. This gives easy slippage as the wood bends to the curve, and prevents dry glue from sticking. Use plastic-resin glue or Urac 185 (American Cyanamid Co.), or a two-part resorcinol formaldehyde, because these glues don't suffer cold creep. Yellow glue and white glue aren't suitable because they will allow the wood to creep under strain. Spread the glue uniformly with a paint roller or a good brush. Be sure the shop is warm enough for the glue to cure.

It is easier to align the layers of wood, and to dry-clamp the setup to be sure it will work, if the forms and the laminates are the same width. If the width of a finished part is to be 2 in., make the stock and the form about 2¾ in. wide. When the glue has set it is easy to cut a ¼-in. layer off both sides of the blank and joint or hand-plane the sawn faces. This avoids the necessity of scraping off squeezed-out glue and the risk of nicking a good plane iron on hardened dribble.

After some experience with these methods, it is tempting to introduce all sorts of perturbations and various odd lumps of wood to go around joints here and there. But I have found that it is better not to introduce many complex forms, and to prefer simpler design. □



Use the form and shims to lay out the finished width on the lamination and bandsaw to size.