Fine Homebuilding
February/March 1998 No. 114

Building Finish Stairs

With a housed stringer on one side and an open, mitered stringer on the other, these stairs look harder to build than they are

by Andy Engel

Deterred by the seamless look of formal stairs, many carpenters never attempt to build them. But no phase of stairbuilding requires special skills. Using a homemade jig and a router to mortise the housed stringer, a journeyman carpenter can build stairs with the tools found in most garage woodshops.

I had often marveled at the seamless construction of finish stairs (top photo, facing page). The rounded, tapering mortises in the housed stringer seemed to be made by sorcery, or at least by expensive, specialized machines. Then, ten or 12 years ago, I read a review of a stair-routing jig. This simple $132 aluminum jig was an epiphany, and I bought one the next day. I built a few sets of stairs with it but found its rise-and-run range was too limited. Frustrated, I made a jig from ¾-in. plywood. The store-bought jig hasn't been out of its drawer since.

It's easier to build stairs in the shop—Most finish stairs that I've built have an open, mitered stringer on the outside and a housed stringer, where the risers and treads are glued and wedged into mortises, on the wall side. I usually built them in my shop because my tools were all at hand. Shop-built stairs call for careful measurements. If built to the wrong size, they can take up valuable shop space for a long time before you find a house they do fit. Measuring for stairs and ciphering rise and run are beyond the scope of this article. See *FHB* #100 (pp. 54-57) for a primer on stair layout.

I make the stringers from 5/4 stock because I can get clear, long lengths of dried and surfaced

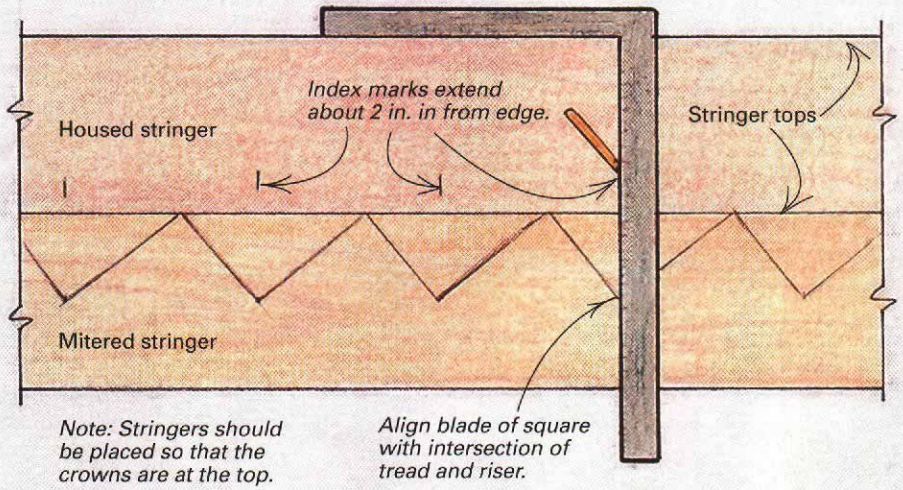
Trimming the tread to the miter. A framing square guides the circular saw, and the cut is finished with a handsaw.

Gang-cutting the treads for mitered returns. The author clamps all the treads together with their edges flush and square. He then screws a scrap-wood guide to their end. With the saw set at 45° and its cutting depth at the return width, he miters all the treads with one cut.

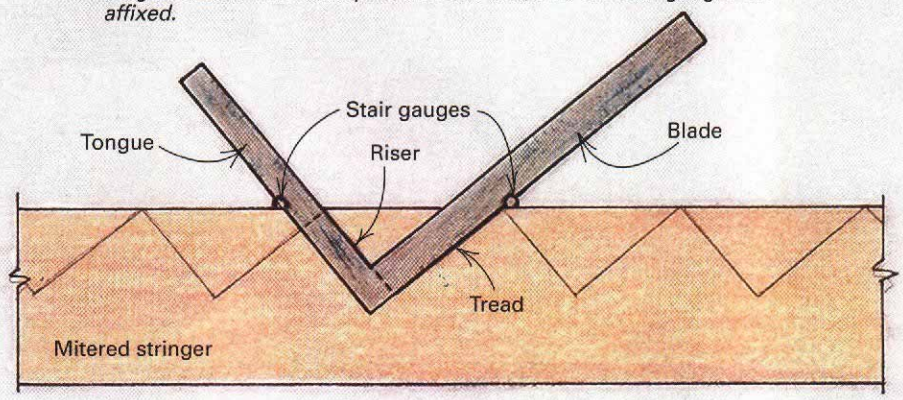
Photos this page: Patricia Steed. Top photo facing page: Andy Engel.

Laying out the housed stringer. *After the mitered stringer is laid out, its top is held against the bottom of the housed stringer.*

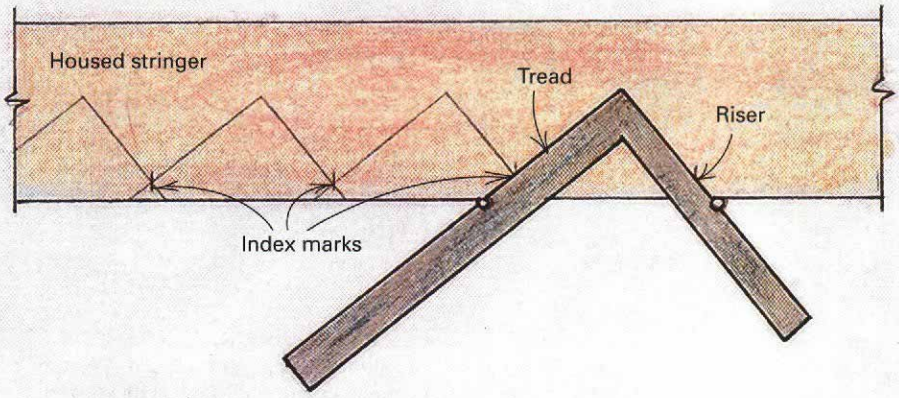
1. The housed stringer is marked as shown in the drawing. These notations are index marks to keep the tread-and-riser intersections consistent between the stringers and to avoid accumulated error.



2. To position the stair gauges on the square, the blade of the framing square is lined up on top of a tread layout on the mitered stringer. Its tongue is then slid 1½ in. past the riser line, and the stair gauges are affixed.



3. The author butts the stair gauges to the housed stringer, and he aligns the riser and tread dimensions with the first set of index marks. He then marks the outside of the square on the stringer with a pencil. The square is moved to the next set of index marks, and the process is repeated. Don't reverse the square—the layout would then be upside down.



material. Nominal 10-in. stock is plenty strong for the housed stringer, but I use 5/4x12 for the mitered stringer. Even so, the notches will weaken it so that it must be supported by a wall. The inside of this wall is usually flush with the edge of the stairwell, and it's typically built after the stair is set. Plan the stair width so that the mitered stringer overhangs the wall enough for drywall to slide behind it.

The treads and stringers on this stair are 5/4x12 yellow pine. Where I worked in New Jersey, it's sold in lengths from 6 ft. to 16 ft., bullnose for use as stair tread. It also makes good stringers; it's strong, and it's usually the least expensive clear pine available. When using it for stringers, I simply rip the stock to width on my table saw and save the rippings for tread returns.

Mitering the treads and risers—I usually make the risers from 1x10 or 1x8 stock, depending on which generates the least scrap. I first square-cut the risers about an inch oversize. This way, I can look at them individually and decide which edge to trim when I rip the risers to width. Then I set the table-saw fence to the riser dimension and rip all but two risers to width.

The bottom riser is one tread thickness narrower than the others so that the first step will be consistent with the rest. The top riser is generally ¼ in. wider than the others because the top landing tread is a transition between the stairs and the finish flooring. In my area, lumberyards commonly stock landing treads that are 3½ in. wide and have a 1-in. thick nose that matches the treads. Their backs are rabbeted to ¾ in. to match hardwood flooring and extend over the top riser to rest on the subfloor.

The risers join to the outer stringer with a miter. I mark the actual length on the risers and miter them, making sure that the crown will be up and the best face out. I use a 12-in. miter saw, but a radial-arm saw, table saw or even a portable circular saw will do the job.

I select the flattest stock for treads to minimize the sanding required to make the return and the tread flush on top. I rip and crosscut the treads to size and then, for a stain-grade stair, miter the outer edge of the treads to receive the return. The quickest, most accurate way I've found to do this is gang-cutting (photo right, p. 61).

I stack the treads, crowns up, and clamp them in a square, flush-edged pile that stands on the ends that will go in the housed stringer. I set the circular saw at 45° and its depth of cut to the nosing overhang, 1¼ in. I register the saw against a straight piece of scrap screwed to the treads' end grain. The outside of the blade should just kiss the front of the treads.

After cutting and unclamping the treads, I square-cut them to the miter with a circular saw guided by a clamped framing square (photo left,

Drawings: Chuck Lockhart

Cutting the mitered stringer. After making all the riser cuts with the circular saw set at 45°, the author cuts the stringer for the treads with the saw set at 90°. A handsaw finishes the cuts.

p. 61). I stop the square cut just as it intersects the 45° cut and finish with a handsaw. The stock for the tread returns comes from the bullnose edge of the wall stringer. The returns are 1 ¼ in. wide, leaving a piece of 5/4 stock 9 ⅞ in. wide, plenty for the wall stringer. For the outer mitered stringer, I rip only enough to square the edge. Because notching will weaken this stringer, it should remain as beefy as possible.

I cut the return stock to length, 45° on one end and square on the other, 1 ½ in. longer than the tread width. I bullnose the ends of the returns with a miter gauge and a rounding bit in a router table. I nail the returns to the treads with two 6d finish nails, one near the front and one near the back, being careful not to nail where I'll later drill for balusters. I glue the return to the tread at the miter and for maybe an inch behind it, but no more. This practice allows the tread to move a little without cracking. I sand the joint flush after the glue dries.

Using a square to lay out the stringers— I look the stringer stock over for crown, bow and best side. Crowns go up, bows oppose each other, and best sides show. I lay out the mitered stringer using a framing square and stair gauges. It's a standard layout, so I won't go into detail about doing it. The only difference from an unmitered stringer is that the layout represents the fronts of the risers, not their backs. But this doesn't require any changes. Simply set the stair gauges on your framing square to the rise and run, and go.

The housed stringer is a little different (drawings, facing page). It's laid out from the bottom of the stringer, not the top. The layout lines represent the front of the risers and the top of the treads—you don't subtract a tread thickness from the bottom-riser layout because of this. And the treads and risers don't intersect at either edge of the stringer. Because the layout represents the tops of the treads and the fronts of the risers, the intersection of the treads and risers at the back of the step has to be well within the stringer. Otherwise, the treads and risers would hang below the stringer. And if they intersected at the top, it would look like a notched stringer.

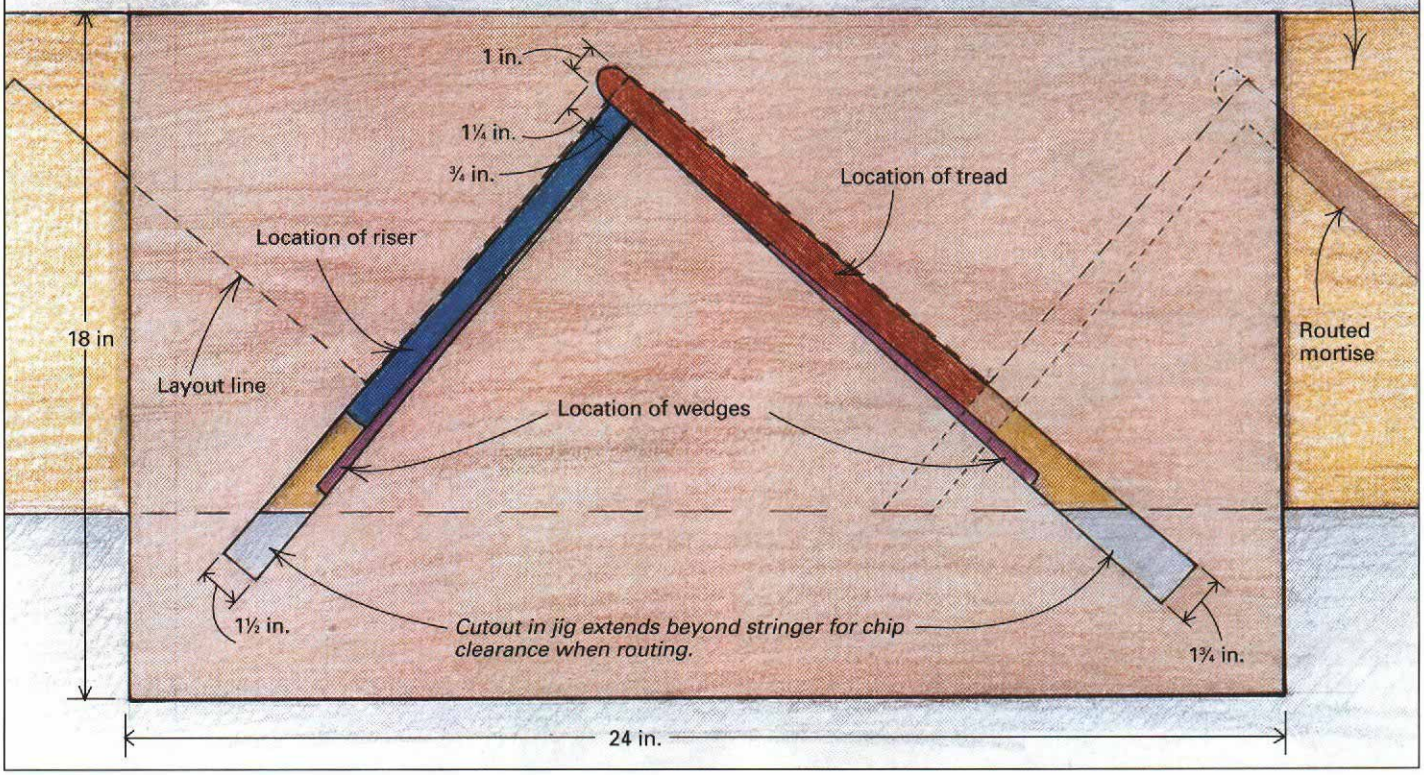
Thoughtful layout can hide cosmetic defects such as knots in the stringers. I try to make knots fall in the notches of the mitered stringer or behind the treads and risers of the housed stringer. Now is the time to think about how the base molding will integrate with the stringer, too. I like the plumb cut to match the height of the bottom of a two-part base so that the cap continues smoothly from the base to the stringer.

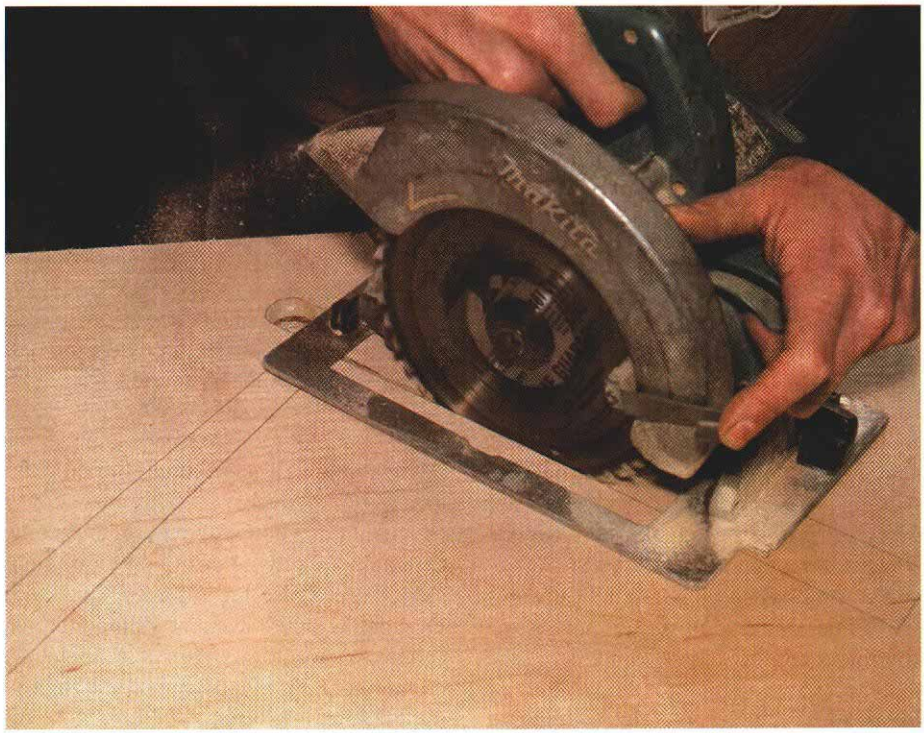
Mitering the stringer with a circular saw— I notch the mitered stringer with a circular saw (photo above left). You can clamp a guide to the stringer if you aren't confident of cutting a straight line. I set the blade square to make the cut for the treads and at 45° to miter the stringer for the risers. I finish the cuts with a handsaw (photo above right). If the mitered stringer is on the right-hand side as you look at the stair from the bottom, a sidewinder circular saw will miter the risers just fine. If it's on the left, you'll need a worm-drive saw. Or you could use a handsaw for either side. I've done that, and it's why I now own two circular saws. I save the triangular cutouts and use them for glue blocks later.

Making the jig to mortise the housed stringer— I mortise the housed stringer for the treads and risers with a homemade plywood jig and a plunge router (bottom photo, p. 60). The jig is made from a piece of ¾-in. birch plywood. The type of plywood doesn't matter as long as it's smooth on both sides and is free of voids. It

A jig for mortising stringers

Made from ¾-in. birch plywood, this simple jig is used with a pattern-routing bit in a plunge router to mortise the housed stringer. This jig works for 1-in. thick treads and ¾-in. thick risers.





Drilling a hole the same radius as the tread's bullnose is the first step in cutting the jig. The rest of the jig is plunge-cut with a circular saw and finished with a jigsaw. A steady hand is required; any mistakes here will telegraph to the finished stringer.

Photos this page: Patricia Steed

should measure about 18 in. by 24 in. With a framing square and a pencil, I lay out the jig as shown in the drawing on the facing page. The cutout in the jig has to be wider than the stringer so that the bit isn't in contact with the stringer when you start the router. This extra space also gives the chips an escape route.

The backs of the mortises have to taper to take a wedge. For a 9-in. run, the wedges measure 8½ in. long, proportionately longer for wider treads, ⅛ in. thick at the point and 9/16 in. at the butt. I cut the scrap from the risers into 8½-in. long pieces. Then I cut the wedges from these on a 12-in. miter saw by setting it to half of the wedge angle and flipping the stock after each cut (photo right). You can use the same technique with a miter gauge on a table saw. Don't get greedy. I stop when I've cut about two-thirds of it into wedges. It feels dangerous to do more.

I hold a wedge along the underside of the tread marking and trace it onto the jig, repeating this at the back of the riser mark. I keep the wedges back about ½ in. from the intersection of the tread and riser. The wedges compress as they're driven in, and this ½-in. space keeps them from hitting the tread or riser before they're tight. Ideally, the driven wedges should just touch each other. Extend these angled lines, and you're ready to cut the jig.

I clamp the plywood to a piece of scrap so that it doesn't splinter when cut. I drill the front of the jig with a spade bit that matches the radius of the bullnose (photo left, facing page). Then I plunge-cut the jig with a circular saw (photo right, facing page) and finish the cuts with a jigsaw. These cuts have to be good—any mistakes here will show on the stairs.

Mortising the housed stringer—I clamp the stringer to my sawhorses and hold the jig on the layout lines with two C-clamps. I work from the top edge of the stringer and from right to left. After the first cut, I start all the cuts in previously routed mortises at the corner where the treads and risers will meet. By starting there, the corner doesn't chip as it would if I finished the cut there. And the inevitable blowouts from the router exiting the cut happen behind the treads and risers where they aren't noticeable. The mortises should be about ⅜ in. deep.

I use a heavy-duty plunge router with a ¾-in. pattern-cutting bit, one with the bearing mounted above the cutting edges. I take at least two passes. Raise and lower the bit beyond the stringer and away from the edges of the jig—it's easy to ruin the jig accidentally. If you aren't experienced using a router and a big bit, you should practice on some scrap and learn how the tool handles. If you use heavier stringer stock, the mortises can be deeper. I leave at least ¾ in. of wood behind the mortise.

A chopsaw cuts the wedges. The angle of cut is set to one-half that of the wedge, and the stock is flipped front to back after each cut. The author judges the width of each wedge by eye. It's important to stop cutting before your fingers get dangerously close to the blade.

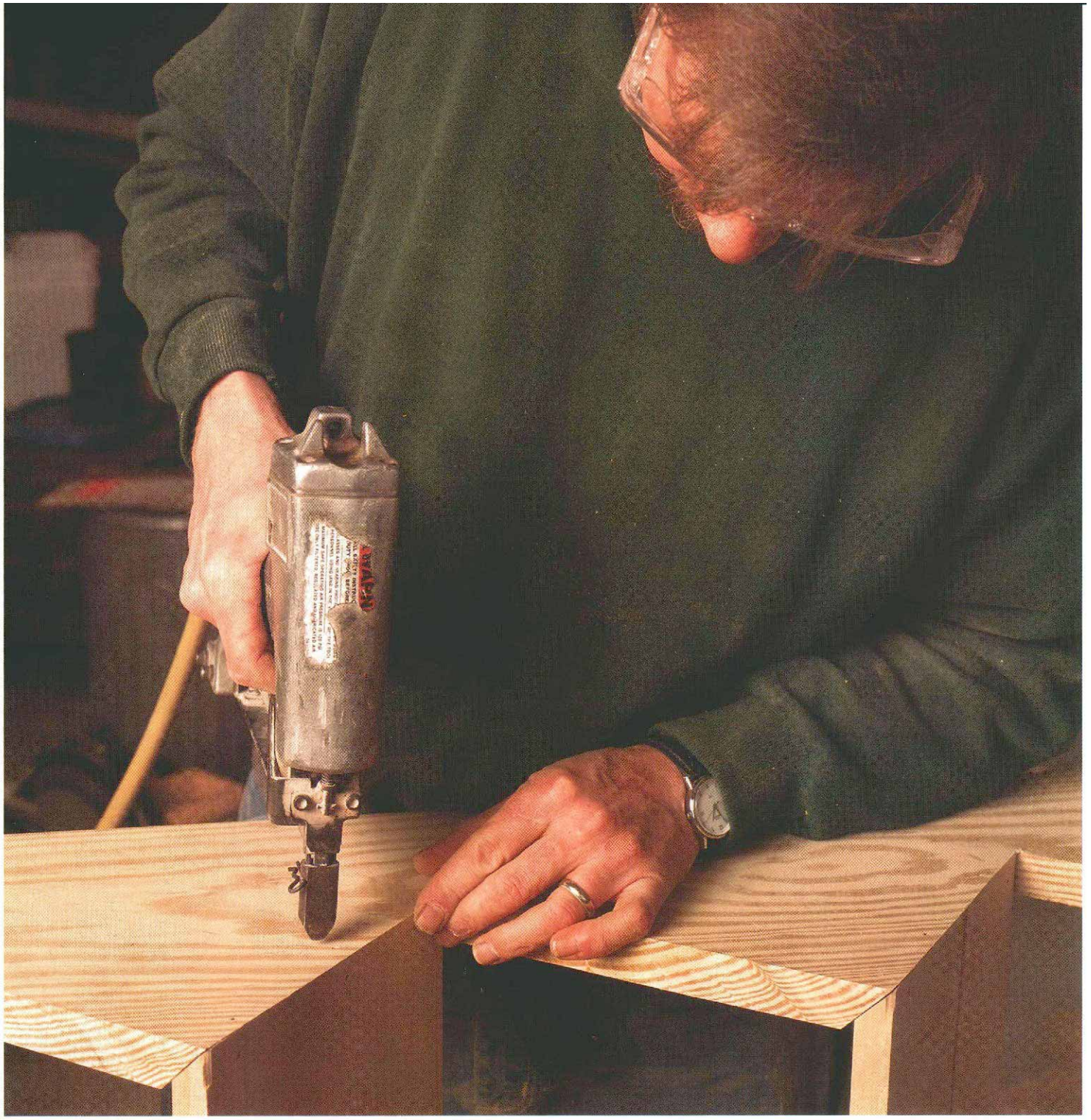
Wedges and glue hold treads and risers in the housed stringer. The glue should flow freely here. It holds the stairs together, and drips won't be visible from the face.

Gathering wedges and glue blocks—It's important to have enough wedges on hand. A typical 13-riser stair will take 25. If it had a housed stringer on both sides, it would need 50. I cut the rippings from the risers into glue blocks to reinforce the tread-to-riser joint. They should fit between the stringers with about 3 in. to spare. Next, I trim the cutouts from the mitered stringer for glue blocks between the mitered stringer and the treads and risers. Trim just enough to make them right triangles with good, square-edged gluing surfaces. The miter saw does this well. I drill three ⅛-in. pilot holes through each block and countersink the holes so that the screws won't split the blocks.

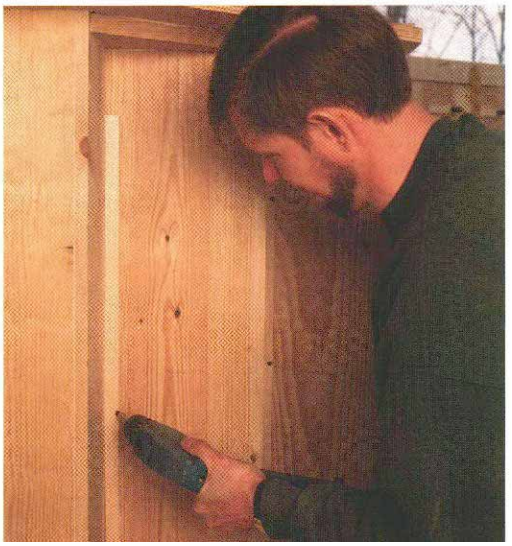
I fill my nail apron with 1⅝-in. drywall screws and 8d finish nails and load the nail gun with 1½-in. nails. I fill a big squeeze bottle with wood glue and have more on hand. Expect to use at least a pint.

Glue and wedges lock the stairs together—With the housed stringer on a flat floor, I put the bottom tread and riser tight together in their

Top photo this page: Patricia Steed



Putting the pieces together. Nailing the miters with a gun leaves one hand free to align the joint (above). A tread is rotated into place (left). Glue and screws from behind will secure it to the riser. Glue blocks (right) unite treads, risers and stringer.



mortises (bottom photo, p. 65). I squeeze enough glue behind the riser to cover both sides of the wedge. Glue holds the stairs together and keeps them from squeaking. I use lots and don't worry about squeeze-out here; it will be hidden. While keeping the riser seated in its mortise, I hammer in the wedge until its butt starts to splinter. Then I pull the tread out and install the rest of the risers the same way. The treads go in later.

Keeping the risers and treads seated in their mortises is crucial. Their square cuts are what keep the stairs square.

The next step is easier with a helper, but not impossible alone with a nail gun. I nail the mitered stringer to the risers with 1½-in. finish nails through the miters (top photo, facing page). It isn't necessary to glue the miters. Glue blocks from behind will reinforce them with little chance of glue dripping on the finished surfaces. I keep the joints between the risers and stringer flush; otherwise, the returns on the treads may not fit tightly to the stringer. It's easiest to sand these miters before installing the treads.

Next, I run a bead of glue down the back of the first tread. I stay toward its bottom to minimize squeeze-out; it will show here. I put the nose of the tread in the mortise with its other end flat on the notch and rotate the tread into place (photo bottom left, facing page). I check that the overhanging end on the return fits tightly to the mitered stringer. If it doesn't, I remove the tread and trim some from the housed end. Bracing the stringer with my body, I drive 8d finish nails through the tread into the mitered stringer, being mindful of where I'll later drill for balusters. Moving to the housed stringer, I spread glue in the mortise and then wedge the tread in place.

I make four dimples in the back of the riser using the tip of my screw gun as a countersink. The dimples reduce the splitting caused by the bugle-head drywall screws. I screw the riser to the tread with 1⅝-in. drywall screws through the dimples. I check the front to be sure the connection is tight, and if there are gaps, I add more screws. I wipe up any escaping glue and proceed to the next tread. I leave the landing tread off for now. It's easier to install after the newel post has been set.

Before proceeding, I check that all the treads are flat on the mitered stringer. If any aren't, I screw an angled block to the stringer bottom for bearing, clamp the tread down and add more nails. Then I wipe up any glue that's made a break for it since I last looked.

Scotia molding hides gaps. The author nails the scotia to the stringer and tread with 1¼-in. nails. They're too short to come through the top of the tread.

Correct installation matters. Because the stair's notches weaken the mitered stringer, the author frames a wall to support the stair as part of the stair installation. Blocking behind the wall stringer guarantees adequate nailing for the moldings when the stairs are trimmed.

Gluing the treads from below—The treads aren't glued directly to the mitered stringer or to the top of the risers because I find this impossible to do without dripping glue on visible parts of the stair. Instead, I reinforce these joints with glue blocks from underneath. I glue and screw the riser rippings to the back of the joint between the tops of the risers and the treads (photo bottom right, facing page). I leave at least 1 in. between the ripping and the mitered stringer; I'll need this space for other glue blocks. I angle 1⅝-in. screws slightly forward through the ripping into the tread to pull the ripping to the riser.

I spread lots of glue on the two legs and the faces of the triangular blocks cut from the notches, fastening them to the mitered stringer with 1⅝-in. screws through the predrilled holes. They must make full contact with the tread and riser. Because the block is cut at about 45° to the direction of the grain, two gluing rules are fuzzy. The conventions are that glue doesn't hold well on end grain and that gluing wood with its grain perpendicular will cause one or both pieces to split. But this isn't quite end grain, so glue sticks. And they aren't really cross-grain glue joints, so the treads and risers don't crack.

The last step in construction is cutting the cove molding, or scotia, for under the nosings and nailing it in place (top photo). I square the ends of the return pieces, then make a 30° cut from the scotia's bottom to the top of its cove. This leaves the flat at the top of the scotia to continue around and mimic a mitered return.

They had better fit—Setting the stairs is simple. I like to have at least three helpers and arrange them so that one person is up and three are down. If the stair is going over another well, such as for basement stairs, I cover the hole with planks so that no one falls in.

After lifting the stairs into place, I shim the housed stringer away from the studs (usually with ½-in. plywood) to allow drywall to slide behind it. I shim the bottom so that finish flooring can slide snugly underneath. From below, I nail through the housed stringer and shims into the studs with 16d common nails. It's now safe to walk on the housed-stringer side of the stairs, but I think it's safer to stay off the mitered stringer until I build a wall under it (bottom photo).

I usually frame this wall from 2x4s on the flat, shimmed away from the stringer for drywall. I nail the first stud in place in the middle of the stair. Then I have a helper stand on the mitered stringer to prevent it from being wedged upward as I install the rest of the studs.

Finally, I walk up and down the stairs to be certain they work. That's it. Absolutely no sorcery or expensive machinery involved. □

Andy Engel is an assistant editor at Fine Homebuilding *and a former stairbuilder. Photos by Scott Phillips, except where noted.*

Bottom photo this page: Andy Engel