Shopping *for* Pre-Built Stairs

by **B**ill **P**enrod

This pre-fabricated circular stair from Challis Stairways (Sandy, Utah) turns about 180 degrees and terminates in a volute. The laminated curved stringers are mitered to fit against the risers.

We turn out over 10,000 sets of stairs each year from a small shop in Winooski, Vt. Each stair we make is custom-built to match field measurements, but there are really only a few basic types to choose from. For traditional stairs, there are box stairs, which are fully enclosed, and open stairs, which have the stringers partially or fully exposed. For a price, open stairs can be made in a sweeping curve, called a circular stair (not to be confused with a free-standing spiral stair). For a contemporary look, any stair type can be made with open treads.

The simplest and least expensive alternative is the box stair. This fits between two walls (see Figure 1). The basic stair may cost as little as $200 per flight if built with "carpet-grade" materials—typically #2 yellow pine for treads and stringers, and #2 white pine for risers. There are ways to dress up a box stair by leaving them partially or fully open, boxing in the top of the open stringer, and adding balusters and railing.

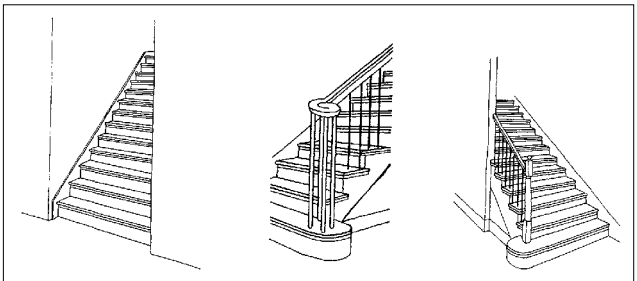
An open stair is more formal, (see Figure 2). On the open side, it has a "skirt" or finish stringer, nosing returns on the treads, and sometimes an elaborate tread bracket. A straight open stair with all clear stock may run about $2,000 plus the cost of trim, which can easily add another $800 to $1,500 for formal colonial woodwork.

A half-open stair is simply an open stair that becomes a closed box stair halfway up (Figure 3). A double-open stair is fully open on both sides—usually creating a dramatic design element.

Curving a stair will naturally add significant cost. For example, a three-quarter-turn wood circular (not spiral) stair with wood rails will run from $5,000 to over $12,000 depending on the detailing and materials used. (We've installed more circular stairs in the last four years than in the previous fifteen, due to increased demand.)

Another trend is the current interest in modern open-tread or *alpine* designs (see photo). These can be boxed in, but are often free-standing. Here the treads are fit into routed stringers and lagged from the outside of the stringer. Wood plugs conceal the lags.

Finally there are spiral stairs. These provide the way to get from one floor to the next with the least amount of lost floor space. They are the least functional and least comfortable stair—but for some they are a conversation piece.



1. *The box stair is the simplest and least expensive choice.*

2. *An open stair is more formal—and more costly—than a box stair. The railing terminates here with a volute.*

3. *A half-open stair offers a good compromise between economy and elegance.*

Materials

Nearly all stair parts, nowadays, are made from laminated material. For example, a tread usually has two or three laminates. Although some customers ask for "solid" wood for appearance, it is much less stable, and more likely to "walk around" when the indoor humidity changes. Trim parts are generally laminated as well.

Our standard stair uses southern yellow pine for the stringers and treads, and native white pine for the risers. We use the yellow pine because it is strong and durable, and relatively inexpensive. We use clear grades for exposed wood and #2 if the stair will be carpeted. If the carpet will be a runner up the middle of

Top **F**light **B**usinessman

Ron Clark for Business Digest

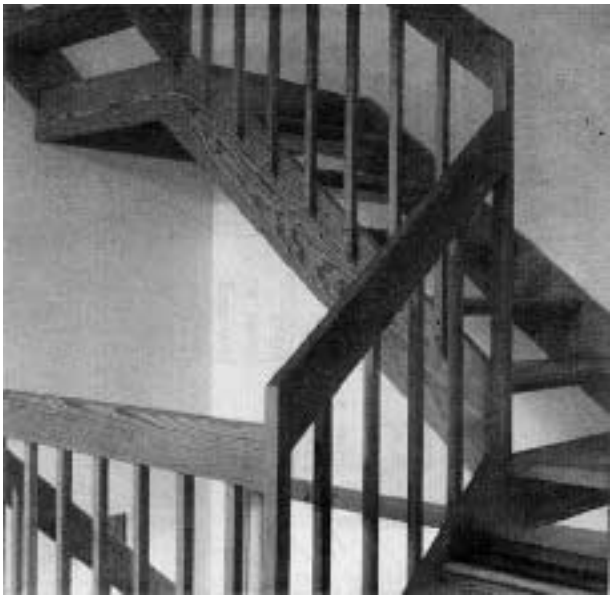
Bill Penrod started his stair business in 1968 taking orders from contractors in Vermont, and hauling pre built stairs up from New York City on the top of his Rambler. In 1973 Penrod began to manufacture the stairs himself to give himself better control over costs and quality. Now his company, working out of a small shop in Winooski, Vt., turns out over 10,000 sets of stairs per year—about half to builders in need of a single set of stairs and half to developers looking for 50 to 200 sets of stairs.

Each set of stairs is custom-built according to measurements that Penrod's salesmen make in the field. Very rarely will they work from a plan or someone else's measurements. That enables the company to guarantee its customers 100 percent satisfaction, which starts with a stair that fits the opening. "If I'm going to eat a job due to bad measurement," he says, "I want it to be my bad measurement." A misfitting stair, he says, is rare—less than one percent. "But," he adds "we all know how 6 inches measured in the field can mysteriously become 76 inches in the shop."

On one job, for example, the bottom of a stringer on a box stair stuck out past the partition a couple of inches. Even though the plans called for a longer partition—that would have made the stairs fit— Penrod' crew went back and modified the stair to fit. They cut off the bottom step and added a bull-nose starting tread with a newel post.

Besides his emphasis on service, Penrod builds a good-quality, competitively priced stair. Above, he shares some of his insights into what to look for in a stair and what some of your options are in stair buying and building.

—NEB



In this open tread or "alpine" design, built by the author, the landing header and inner stringer are joined with an oversized mortise-and-tenon. If this joint is not reinforced, it will sag, as is the case in many older stairs with suspended landings.

the stairs, one alternative is to use construction-grade treads and risers and a thin hardwood "tread cap" up the stairs on either side of the carpeting.

Construction techniques

There are essentially two ways to build a stair. One—commonly used for site-built stairs today, is to face nail the treads and risers to a 2x structural member (the carriage or horse), which is notched to carry the stairs (Figure 4). Finish stringers or "skirts" are 1x stock added for decoration.

Our stair, like most pre-built stairs today, consists of "housed stringers" into which the treads and risers are secured with glued wedges (Figures 5 and 6). The stringers and treads are typically a full inch thick (5/4 stock). This type of stair uses no face nailing. The wedges and glue hold the treads and risers in the stringers. The risers are nailed or screwed to the tread below and notched into the tread above. If the tread spans more than 3 feet, we add a central carriage.

We cut the dadoes—into which the treads and risers fit—with a slight backcut so that the wedges cannot slip sideways. The wedges are cut with a bevel to fit the notches. This locks the treads and risers into the stringers.

This type of construction—with housed stringers and glued wedges—makes the stair act like a single unit, so when the new home shrinks and moves, it tends to move around the stair.

A built-in-place stair, supported on carriages, is more prone to move around as the house settles. The treads may pull away from the skirt, which is nailed to the studs. Also, the stair may develop creaks if the carriages shrink away from the treads.

More details

Most stairs require glue blocks between the tread and riser—no more that 6 inches apart. Since they cannot be clamped, we sometimes tack them in place with a brad gun to hold them until the glue sets. The glue blocks tie the tread and risers together into one unit and stiffen the stairs. This also deadens the sound when the stairs are used.

Each riser is dadoed into the tread above to help keep it in place. Often the treads are dadoed into the riser behind. We find that this last step is not necessary as long as the riser is well nailed or screwed to the tread.

Installation

Except for stairs open on both sides, the studs hold a stair more than the joints at the top and bottom of the stringers. In general, we recommend one 16d nail through the back of the housed stringer into each stud.

Our stairs are designed to sit right on the top header, (see Figure 7) so that the

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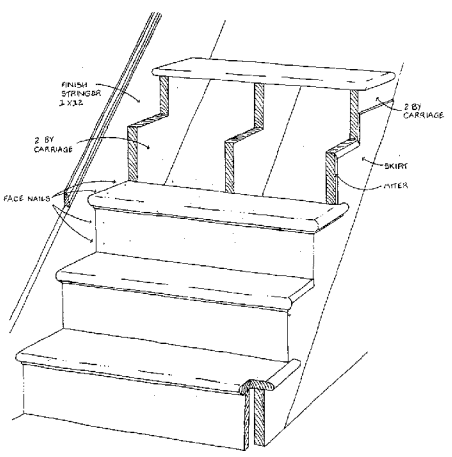
This stair—typical of a site-built model—sits on 2x carriages. The finish stringer at left goes in first. Treads and risers are face-nailed. The skirt, like an open stringer, is mitered to fit against the riser.



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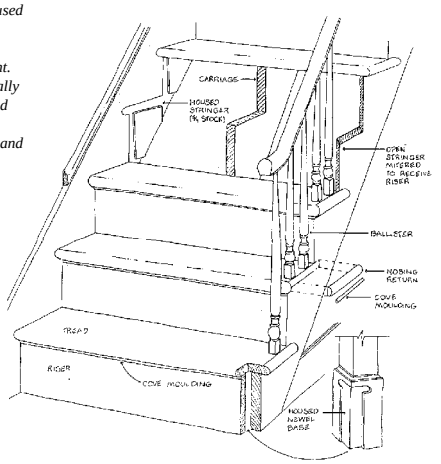
This stair—typical of a factory-built model—uses a housed stringer on the left side and an open stringer on the right. Stringers are typically 5/4-inch stock, and serve as both structural support and finish work.



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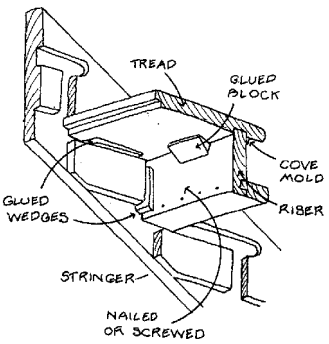
Dadoes in housed stringers should be slightly back-cut with a dovetail bit. If wedges are cut at a matching angle and driven in with glue, they should hold the treads and risers in place permanently without nails.



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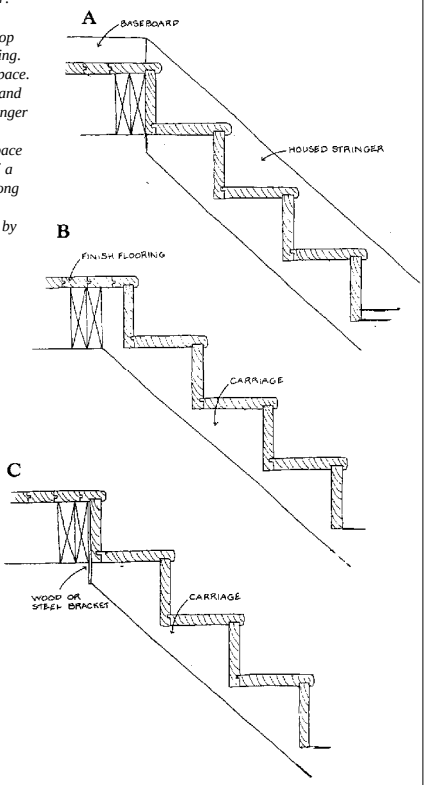
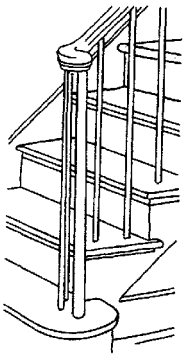
Three ways to hang a stair: System A uses a housed stringer and lines up the top tread with the finish flooring. This is strong and saves space. System B uses a carriage and is strong, but requires a longer opening (by a half-tread width). System C saves space but hangs the carriage off a bracket. This is okay as long as the carriage is well-supported along its length by nailing into the studs.





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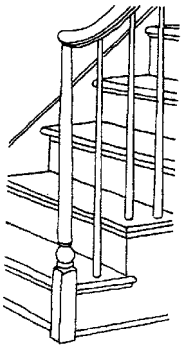
The turnout (left) and easing (right) are simple, traditional ways to terminate the balustrade. Other options are the newel post and volute, shown elsewhere.



top tread goes flush with the last piece of flooring, and the stringer meets the baseboard. This makes a strong and clean transition from stair to floor.

A site-built stair is typically hung at the top by cutting the last step in half—and toenailing it to the header. This is adequate, but wastes a half tread's worth of run—requiring a longer stair opening. An alternative is to drop the carriage down and hang it from the bottom of the header.

In many cases, the stair will not go from floor to floor, but from floor to landing. All such landings should be built like small floors. In some cases, (see alpine stair) one corner of the landing is hanging out in space—supported primarily by the stringer below it. In many old houses, these are sagging. They sag because the joint where the stringer meets the landing beam was not made strong enough. Steel supports, laminated wood, dowels, or some other adequate joint is needed here.

A pre-built stair should go in before the drywall. This presents one significant problem: protecting that nice new wood from getting massacred by a careless crew. It's a good idea to cover it first with a membrane such as polyethylene, then tack on a rigid covering such as particleboard. Another workable solution is to temporarily install old carpeting.

The stairs can be finished before or after installation. I like to apply finish to a stair set level on two saw horses before installation. It means a lot less bending over.

The Trim

The trim is often the most difficult procedure in any stair case. It often costs as much or more than the stairs themselves. A fully dressed-up formal open stair can easily run $500 to $900 in trim materials plus two days labor for two skilled carpenters.

Installing trim is a specialty and will test the skill of any carpenter who is not experienced at the job. The trick, in general, is to lay out the entire rail over the stairs, assemble it in place, then lift it up into position while the balusters and newel posts are installed.

There are several major suppliers of hardwood stair parts (see list at end of article). Looking through their catalogs is a good way to get familiar with the options. For example, at the bottom of a stair, you can have a simple newel, a volute, a turnout, or an easing (Figure 8). It's a matter of taste and cost.

If your design calls for a curved railing, you'll need to have this custom-fabricated, and the cost is likely to exceed $1200 just for the railing. A simple curved rail such as on a curved landing, though, can be glued up using a "bending rail" available from most stair-parts suppliers.

Codes

We often have customers ask us for stairs that are uncomfortable, not functional, or not legal by code. The rules regarding stairs are pretty straightforward (see table on dimensions). But once the opening is framed in, there's little a stair builder can do with an opening that's too small, or a ceiling that's too low. It's like the story about the princess with the big feet who wanted small shoes—they can't fit. The important thing is to plan ahead. Talk to your stair builder when you are designing the building—not after you find yourself with a too-small opening. ■

Residential Stair Dimensions

	FHA	BOCA	Preferred
Min. width	32"	36"	42"
Min. headroom*	6'8"	6'8"	7'4" to 7'7"
Max riser	8 1/4"	8'4"	6 1/2 to 7 1/2"
Min. tread run	9"	9"	10" to 11"

Notes:
Ideally, the slope of a residential stairway should fall between 30 and 37 degrees, and the rise plus the run should equal about 17-1/2".

BOCA requires that adjacent treads or adjacent risers vary by no more than 3/16". Maximum variation between largest and smallest should not exceed 3/8".

*Measured vertically from the tread nosing.

Bill Penrod owns and operates Penrod Stairways in Winooski, Vt.

Product Information:

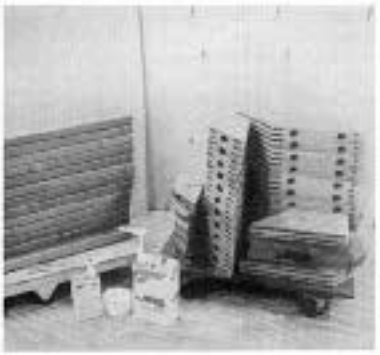
Major suppliers of stair trim and components include:

Challis Stairways, Inc.
11585 South State
Sandy, UT 84070

Morgan Products, Ltd.
P.O. Box 2446
Oshkosh, WI 54903

Visador Company, Marion Div.
1000 Industrial Road
Marion, VA 24354

The finished circular stairway turns 90 degrees. The radius of the outer stringer is 89 inches.



Cut on the author's radial-arm saw, all the pieces lay ready for gluing with West System epoxy.

CIRCULAR STAIRCASE *with a* NEW TWIST

by Peter Domenicali

Domenicali tells the story of a circular staircase he recently completed with helical stringers and handrails built up from short parallelogram-shaped segments, butt-joined with double spline reinforcement.

The Original Design: Heavy Metal

The original design by the architect specified 3/8-inch-thick welded steel treads and stringers. The treads were to be carpeted and the stringers were to be wrapped with three layers of 3/8-inch plywood, screwed to the steel, followed by 3/8-inch butternut tongue-and-groove paneling (butternut has been chosen for all interior doors and trim). However, the design seemed cumbersome and labor-intensive, and the owners decided they wanted the warmth and integrity of solid wood construction. It was at this point that the contractor called me to explore the feasibility and cost of a solid butternut circular staircase, with open-risers, turning a total angle of 90 degrees. The outer stringer radius was to be 89 inches and an inner stringer radius was to be 47 inches.

Conventional Construction is Laminated

Typically the fabrication of helical stringers for a circular staircase involves laminating several thin layers of wood on a form that is basically a curved stud-wall. Separate forms must be built for the inner and outer stringers, and the handrails are laminated on these same forms. The height of the forms must be somewhat greater than the finished height of the staircase, to allow for end-trimming. A jig must be constructed for routing the tread mortises on the curved stringer surfaces, and the baluster holes must be bored at the proper angle and position in both the stringers and the handrails. Finally, the top and bottom ends of the curved stringers must be accurately laid out and cut to length.

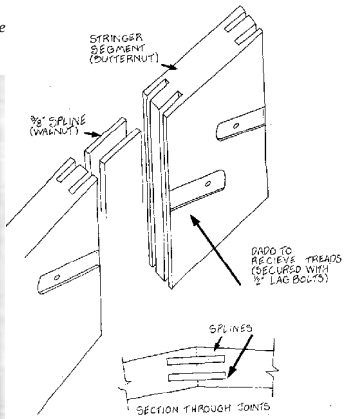
There Must be Another Way

While I knew that many people had built laminated-stringer staircases and had evidently coped with all of these difficulties, I couldn't help thinking that there must be another way. For one thing, I had no experience with bending wood or lamination, and therefore was concerned about how much to allow for "springback." Also, the ceiling height in my shop is only 8-1/2 feet, so I would have to build the forms and do the lamination somewhere else. The wood specified, butternut, is not commonly available in long, clear specimens. And the design called for a multiple beading detail on the outer surfaces of the stringers, which had to align with a similar pattern on the fascia (the edge of the upper floor), and which seemed impossible to do with a router. In any case, once I had hit upon the butted-segment concept, it seemed so novel I just had to try it. So I built a quarter-scale model in white ash to see how it would look and how the parts might go together. The owners liked the model and approved the deviation from true curved surfaces.

Chain is Only as Strong...

We all know a butt joint, even double-splined, is not as strong as continuous wood. But I felt that if I could determine the stresses in the stringers under the maximum expected load, and then test some sample joints using those stresses, then I could arrive at dimensions for the stringers and splines that I could comfortably expect to withstand the load. LeMessurier Consultants, of Cambridge, Massachusetts, performed a computer simulation of the staircase. They had a program that took the dimensions of the staircase, the modulus of the wood, and the end conditions, and calculated the deflections and stresses at various points along the stringers. Although the program assumed the stringers were solid, unjointed

While a bar clamp applies pressure to close up the joints (above), two hand-screws with beveled jaw-pads clamp the cheek of the mortises. The finished joint (left) contrasts the butternut stringer with walnut splines.



Quarter-inch lag bolts into the treads work along with the splines to strengthen and stiffen the stair.

wood. I felt that the stresses arrived at would be valid since the joints would only marginally affect the stiffness of the stringers. The simulation predicted that the most severe stresses would be due to torsion in the stringers. Based on the computer's output and the tested strength of some sample joints (about half as strong in torsion as solid samples), I settled on a stringer thickness of 2 inches with double 3/8-inch-thick splines.

Putting it All Together

Finding the butternut stock for the stringers was a project in itself. I ended up going to a sawmill that happened to have two large butternut logs in the yard, having them sawn into 11- to 15-inch-wide by 2-1/2-inch-thick planks, and then getting the planks dried in under 2 weeks, using a low-temperature vacuum-drying process.

I used walnut for the splines to create a contrast, as the owners felt the splines would add visual interest to the design.

Machining the stringer segments and treads required precise machine setups and accurate measurements, but it was all done with a table saw, a radial arm saw, a drill press, and a router. The splines were sized to slide smoothly into the grooves.

I assembled the handrails first using aliphatic-resin (yellow) glue. Angled clamp blocks let me apply the clamping force directly across the joint. After a few practice joints the assembly process became routine, if somewhat hectic.

For the stringer assembly I switched to West system epoxy (Gougeon Brothers, Inc., P.O. Box X908, Bay City, MI 48707; 517/684-7286) because of its long-term creep resistance and longer set-up time. The treads were housed in mortises in the stringers and secured with two 1/2-inch lag bolts at each end. Since the joints fell on the centerlines of the treads, the treads helped hold the joints together. As the staircase took shape in my shop I began to wonder whether it would fit in my Maxi-van for delivery to the site. It did, barely.

The Proof is in the Pudding

The finished staircase fit in place with minor scribe-fitting to the fascia and floor. Custom-steel U-brackets securely anchored the top and bottom ends of the stringers. Installation of the balusters and rails was quite straightforward since the baluster holes were already drilled.

To test the stiffness of the staircase, I measured the deflection halfway up the outer stringer with a 200-pound man on the adjacent tread; it was less than 1/16th of an inch. All those who have used the staircase report that it feels quite rigid underfoot.

I've been asked if I would do it again. I certainly would. A great deal of the time spent on this project was due to the choice of butternut for load-carrying members. If I build another circular staircase I will insist on ash or oak for the stringers, and I will have the steep part of the learning curve behind me.

The success of this project owes a lot to the contractor, who supported this novel (and unproven) approach, as well as to the owners, who had faith me from the start and gave me the chance to explore this new design. ■

Peter Domenicali is a woodworker in Montpelier, Vermont. He specializes in staircases.