Chapter 1

Stairs

Anyone who has tried to build stairs has found it to be an art in itself. This chapter is not intended to discourage the builder, but rather to impress upon the builder the fact that unless he first masters the principle of stair layout, he will have many difficulties in the construction. Although stair building is a branch of millwork, the carpenter should know the principles of simple stair layout and construction because of often being called upon to construct porch steps, basement and attic stairs, and other stairs. To follow the instructions intelligently, the carpenter should be familiar with the terms and names of parts used in stair building.

Stair Construction

Stairways should be designed, arranged, and installed to afford safety, adequate headroom, and space for the passage of furniture. In general, there are two types of stairs in a house: those serving as principal stairs and those used as service stairs. The principal stairs are designed to provide ease and comfort and are often made a feature of design. The service stairs leading to the basement or attic are usually somewhat steeper and constructed of less-expensive materials.

Stairs may be built in place, or they may be built as units in the shop and set in place. Both methods have their advantages and disadvantages, and custom varies with locality. Stairways may have a straight continuous run, with or without an intermediate platform, or they may consist of two or more runs at angles to each other. In the best and safest practice, a platform is introduced at the angles, and the radiating risers are called winders. Winder stairways are hazardous.

Ratio of Riser to Tread

There is a definite relationship between the height of a riser and the width of a tread, and all stairs should be laid out to conform to the well-established rules governing this relationship. If the combination of run and rise is too great, the steps are tiring, placing a strain on the leg muscles and on the heart. If the steps are too short, the foot may kick the leg riser at each step, and an attempt to shorten the stride may be tiring. Experience has proved that a riser 7 to 7\(\frac{1}{2}\) inches high, with appropriate tread, combines both comfort and safety, and these limits therefore determine the standard height of risers commonly used for principal stairs. Service stairs may be narrower...
and steeper than the principal stairs, and are often unduly so, but it is a good idea not to exceed 8 inches for the risers.

As the height of the riser is increased, the width of the tread must be decreased for comfortable results. A very good ratio is provided by either of the following rules, which are exclusive of the nosing:

* Tread plus twice the riser equals 25.
* Tread multiplied by the riser equals 75.

A riser of 7\(\frac{1}{2}\) inches therefore, require a tread of 10 inches, and a riser of 6\(\frac{1}{2}\) inches would require a tread 12 inches wide. Treads are rarely made less than 9 inches or more than 12 inches wide. The treads of main stairs should be made of prefinished hardwood. Following are some riser and tread rules to keep in mind:

* The actual riser and tread dimensions for a set of stairs are determined by dividing the total rise (or floor-to-floor height) by the desired riser height. The result is rounded off to arrive at a whole number of risers. The total rise is then redivided by this whole number to arrive at the actual riser height.
* This riser height must be checked against the maximum riser height allowed by the building code. If necessary, the number risers can be increased by one and the actual riser height recalculated.
* Once the actual riser height is fixed, the tread run can be determined by using the riser-to-tread proportioning formula.
* Since in any flight of stairs there is always one less tread than the number of risers, the total number of treads and the total run can be easily determined (Table 1-1).

### Design of Stairs

The location and the width of a stairway (together with the platforms) having been determined, the next step is to fix the height of the riser and width of the tread. After a suitable height of riser is chosen, the exact distance between the finish floors of the two stories under consideration is divided by the riser height. If the answer is an even number, the number of risers is thereby determined. It very often happens that the result is uneven, in which case the story height is divided by the whole number next above or below the quotient. The result of this division gives the height of the riser. The tread is then proportioned by one of the rules for ratio of riser to tread.
Table 1-1 Measurement of Riser and Tread

<table>
<thead>
<tr>
<th>Riser Inches (mm)</th>
<th>Tread Inches (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 (125)</td>
<td>15 (380)</td>
</tr>
<tr>
<td>5 1/4 (135)</td>
<td>14 1/2 (370)</td>
</tr>
<tr>
<td>5 1/2 (140)</td>
<td>14 (355)</td>
</tr>
<tr>
<td>5 3/4 (145)</td>
<td>13 1/2 (340)</td>
</tr>
<tr>
<td>6 (150)</td>
<td>13 (330)</td>
</tr>
<tr>
<td>6 1/4 (160)</td>
<td>12 1/2 (320)</td>
</tr>
<tr>
<td>6 1/2 (165)</td>
<td>12 (305)</td>
</tr>
<tr>
<td>6 3/4 (170)</td>
<td>11 1/2 (290)</td>
</tr>
<tr>
<td>7 (180)</td>
<td>11 (280)</td>
</tr>
<tr>
<td>7 1/4 (185) *</td>
<td>10 1/2 (265) *</td>
</tr>
<tr>
<td>7 1/2 (190) *</td>
<td>10 (255) *</td>
</tr>
<tr>
<td>7 3/4 (195) *</td>
<td>9 1/2 (240) *</td>
</tr>
<tr>
<td>8 (205) *</td>
<td>9 (230) *</td>
</tr>
</tbody>
</table>

*These riser and tread dimensions are permitted only for private stairways serving an occupancy of less than 10 and stairways leading to an unoccupied roof.

For example, assume that the total height from one floor to the top of the next floor is 9 feet 6 inches, or 114 inches, and that the riser is to be approximately 7 1/2 inches. The 114 inches would be divided by 7 1/2 inches, which would give 15 1/5 risers. However, the number of risers must be an equal or whole number. Since the nearest whole number is 15, it may be assumed that there are to be 15 risers, in which case 114 divided by 15 equals 7.6 inches. That is approximately 7 9/16 inches for the height of each riser. To determine the width of the tread, multiply the height of the riser by 2 (that is, \(2 \times 7\frac{9}{16} = 15\frac{1}{8}\)), and deduct from 25 (that is, \(25 - 15\frac{1}{8} = 9\frac{7}{16}\) inches).

The headroom is the vertical distance from the top of the tread to the underside of the flight or ceiling above (Figure 1-1). Although it varies with the steepness of the stairs, the minimum allowed would be 6 feet 8 inches.

**Framing of Stairwell**

When large openings are made in the floor (such as for a stairwell), one or more joists must be cut. The location in the floor has a direct bearing on the method of framing the joists.

The principles explained in Chapter 7 of the third book in this series, *Audel Carpenters and Builders Layout, Foundation, and*
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Figure 1-1  Stairway design.

Framing (Hoboken, N.J.: Wiley Publishing, 2005) may be referred to in considering the framing around openings in floors for stairways. (See the Preface for more information on the series.) The framing members around these openings are generally of the same depth as the joists (Figure 1-2).

Figure 1-2  Framing of stairways.

The headers are the short beams at right angles to the regular joists at the end of the floor opening. They are doubled. They support the ends of the joists that have been cut off. Trimmer joists are at the sides of the floor opening and run parallel to the regular joists. They
are doubled. And they are used to support the ends of the headers. Tail joists are joists that run from the headers to the bearing position.

**Stringers or Carriages**
The treads and risers are supported upon stringers, or carriages that are solidly fixed in place and are level and true on the framework of the building. The stringers may be cut or ploughed to fit the outline of the tread and risers. The third stringer should be installed in the middle of the stairs when the treads are less than $1\frac{1}{8}$ inches thick and the stairs are more than 2 feet 2 inches wide. In some cases, rough stringers are used during the construction period. These have rough treads nailed across the stringers for the convenience of workers until the wall finish is applied. There are several forms of stringers classified according to the method of attaching the risers and treads. These different types are cleated, cut, built-up, and rabbeted.

When the wall finish is complete, the finish stairs are erected or built in place. This work is generally done by a stair builder (who is a specialist), but the carpenter also does the job. The wall stringer may be ploughed out, or rabbeted (Figure 1-3), to the exact profile

**Figure 1-3** The housing in the stringer board for the tread and riser.
of the tread, riser, and nosing, with sufficient space at the back to take the wedges. The top of the riser is tongued into the front of the tread and into the bottom of the next riser. The wall stringer is spiked to the inside of the wall. The treads and risers are fitted together and forced into the wall stringer nosing, where they are set tight by driving and gluing the wood wedges behind them. The wall stringer shows above the profiles of the tread and riser as a finish against the wall, and is often made continuous with the baseboard of the upper and lower landing. If the outside stringer is an open stringer, it is cut out to fit the risers and treads and nailed against the outside carriage. The edges of the riser are mitered with the corresponding edges of the stringer, and the nosing of the tread is returned upon its outside edge along the face of the stringer. Another method would be to butt the stringer to the riser and cover the joint with an inexpensive stair bracket.

Figure 1-4 shows a finish stringer nailed in position on the wall and the rough carriage nailed in place against the stringer. If there are walls on both sides of the staircase, the other stringer and carriage would be located in the same way. The risers are nailed to the riser cuts of the carriage on each side and butt against each side of the stringer. The treads are nailed to the tread cuts of the carriage and butt against the stringer. This is the least expensive of the types described and perhaps the best construction to use when the treads and risers are to be nailed to the carriages.

Figure 1-4 Finished wall stringer and carriage.
Figure 1-5A shows another method of fitting the treads and risers to the wall stringers. The stringers are laid out with the same rise and run as the stair carriages, but they are cut out in reverse. The risers are butted and nailed to the riser cuts of the wall stringers, and the assembled stringers and risers are laid over the carriage. Sometimes the treads are allowed to run underneath the tread cut of the stringer. This makes it necessary to notch the tread at the nosing to fit around the stringer (Figure 1-5B).

Figure 1-5  Stringers and treads.
Another form of stringer is the cut-and-mitered type. This is a form of open stringer. The ends of the risers are mitered against the vertical portion of the stringer. This construction is used when the outside stringer is to be finished and must blend with the rest of the casing or skirting board (Figure 1-6). A molding is installed on the edge of the tread and carried around to the side, making an overlap (Figure 1-7).

Figure 1-6 Cut-and-mitered stringer.

**Basement Stairs**

Basement stairs may be built either with or without riser boards. Cutout stringers are probably the most widely used support for the treads, but the tread may be fastened to the stringers by cleats (Figure 1-8). Figure 1-9 shows two methods of terminating basement stairs at the floor line.

**Newels and Handrails**

All stairways should have a handrail from floor to floor. For closed stairways, the rail is attached to the wall with suitable metal brackets. The rails should be set 2 feet 8 inches above the tread at the riser line. Handrails and balusters are used for open stairs and for
open spaces around stairs. The handrail ends against the newel post (Figure 1-10).

Stairs should be laid out so that stock parts may be used for newels, rails, balusters, goosenecks, and turnouts. These parts are a matter of design and appearance, so they may be very plain or elaborate, but they should be in keeping with the style of the house. The balusters are doweled or dovetailed into the treads and, in some
Disappearing Stairs
Where attics are used primarily for storage, and where space for a fixed stairway is not available, hinged or disappearing stairs are often used. Such stairways may be purchased ready to install. They operate through an opening in the ceiling of a hall and swing up into the attic space, out of the way, when not in use. Where such stairs
are to be provided, the attic floor should be designed for regular floor loading.

**Exterior Stairs**

Proportioning of risers and treads in laying out porch steps or approaches to terraces should be as carefully considered as the design of interior stairways. Similar riser-to-tread ratios can be used, however. The riser used in principal exterior steps should be between 6 and 7 inches. The need for a good support or foundation for outside steps is often overlooked. Where wood steps are used, the bottom step should be set in concrete. Where the steps are located over backfill or disturbed ground, the foundation should be carried down to undisturbed ground. Figure 1-11 shows the foundation and details of step treads, handrail, and stringer, and the method of installing them. This type of step is most common in outside porch steps. The material generally used for this type of stair construction is pressure-treated 2 × 4 boards and 2 × 6 boards.
The terms generally used in stair design may be defined as follows:

- **Balusters**—The vertical members supporting the handrail on open stairs (Figure 1-12).
- **Carriage**—The rough timber supporting the treads and risers of wood stairs is sometimes referred to as the string or stringer (Figure 1-13).
Figure 1-12  Vertical balusters support the handrail.

Figure 1-13  Carriage blocks connected to a stair stringer.

- Circular stairs—A staircase with steps planned in a circle, all the steps being winders (Figure 1-14).
- Fillet—A band nailed to the face of a front string below the curve and extending the width of a tread.
- Flight of stairs—The series of steps leading from one landing to another.
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Figure 1-14 A staircase with winding treads.

- Flyers—Steps in a flight of stairs parallel to each other.
- Front string or stringer—The stringer on that side of the stairs over which the handrail is placed.
- Half-space—The interval between two flights of steps in a staircase.
- Handrail—The top finishing piece on the railing intended to be grasped by the hand in ascending and descending. For closed stairs where there is no railing, the handrail is attached to the wall with brackets (Figure 1-15).
- Housing—The notches in the stringboard of a stair for the reception of steps.
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- Landing—The floor at the top or bottom of each story where the flight ends or begins.
- Newel—The main post of the railing at the start of the stairs and the stiffening posts at the angles and platform.
- Nosing—The projection of tread beyond the face of the riser (Figure 1-16).
- Rise—The vertical distance between the treads or for the entire stairs.
- Riser—The board forming the vertical portion of the front of the step (Figure 1-17).
- Run—The total length of stairs including the platform.

Figure 1-15 Various profiles of handrails.

Figure 1-16 The nosing installed to the tread.
Staircase—The whole set of stairs with the side members supporting the steps.

Stairs—The steps used to ascend and descend from one story to another.

Straight flight of stairs—Flight of stairs in which the steps are parallel and at right angles to the strings.

String or stringer—One of the inclined sides of a stair that supports the tread and riser. Also, a similar member (whether a support or not) such as finish stock placed exterior to the carriage on open stairs, and next to the walls on closed stairs, to give finish to the staircase. Open stringers, both rough and finish stock, are cut to follow the lines of the treads and risers. Closed stringers have parallel sides, with the risers and treads being housed into them (Figure 1-18).

Tread—The horizontal face of a step, as shown in Figure 1-17.

Winders—The radiating or wedge-shaped treads at the turn of a stairway.

Building a Curved Stairway

There are a number of unique problems associated with the building of a curved stairway. One of the first thoughts is, “How do I get a handrail to fit the curve of this stairway?”
Figure 1-18  The stair stringer.

In the next series of pictures, you will see how this is done by a very patient carpenter who specializes in this type of problem. This house is built on a slab and there is a second story with an open family room on the first floor leading to a game room on the second. The circular stairway improves the first impression

Figure 1-19  Most of the house has been framed and the stairs are in place.
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Figure 1-20  Note the curved portion of the stair case attached to the floor.

Figure 1-21  Close up view of the prefabricated last step coming down.
Figure 1-22  Stairway enclosed with drywall and step at bottom being installed.
Figure 1-23  First strips being held by clamps from the woodshop.
Figure 1-24 Clamps starting the process upstairs.
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of the foyer and the house as a whole and makes it easy for a builder to sell this type of house once completed and used as a model.

The first step is a prefabricated piece of oak designed for hard use as a landing for all those coming down the stairs. The other steps will be carpeted so no special attention will have to be paid to the treads and risers since they will be covered. Figure 1-19 shows the framing of the area where the stairway will be located. Figure 1-20 shows how the curve has been established on the floor and anchored into the concrete. Figure 1-21 is a closer look at the bottom step before the tread is applied or glued and screwed in place. Note the two bottles of glue that the carpenter will need to bend the handrails to fit the stairway. Figure 1-22 shows the curvature of the stairway.

The first step in bending the handrail begins upstairs where a couple of the strips of oak that are thin enough to bend easily are glued together and clamped to conform to the curve of the stairway (Figure 1-23). Later, more strips will be added, and each time the added strip will be clamped until the glue dries. You can see from this procedure that it takes some time for the job to be done properly.

Figure 1-25 Clamps on the longest run of the gluing process.
Figure 1-24 and Figure 1-25 show clamps and oak strips being bent to conform to the stairway. Figure 1-26 shows how two examples of the wood strips and their molds are assembled to make the handrail when the glue and the process have been completed. The outside pieces of molding strip prevent damage to the oak strips used for the handrail.

![Figure 1-26 Molds that hold the strips of oak being glued.](image)

Figure 1-27 and Figure 1-28 show more of the bending process of making a handrail fit its stairway. Note in Figure 1-29 the handrails have been installed and balusters have begun to take their place in the railing. Figure 1-30, Figure 1-31, and Figure 1-32 show the posts being installed before the hand railing can be attached. Figure 1-33 shows the upstairs balusters installed. Figure 1-34 shows the staircase being utilized as part of the furniture.

![Figure 1-27 Clamps on the other and lower side of the staircase.](image)
Figure 1-28 Clamps holding the glued strips so they form the same curvature as the staircase.
Figure 1-29  Handrails installed and installation of balusters progressing.
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Figure 1-30  Starting the installation of posts.

Figure 1-31  First installation of the handrail.
Figure 1-32 Posts being installed.

Figure 1-33 Handrail and balusters in place.
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Figure 1-34  Finished staircase.
Summary
Stairways should always be designed, arranged, and installed for safety, adequate headroom, and space for passage of furniture. Stairs may be built in place, or they may be built as a complete unit in the shop and set in place.

There is a definite relationship between the height of a riser and the width of a tread. If the steps are too short, the foot may hit the leg riser at each step and an attempt to shorten the stride may be tiring. As the height of the riser is increased, the width of the tread must be decreased for comfortable use.

When openings are made in a floor (such as for a stairwell), headers and trimmer joists must be used to strengthen the floor around the opening. Stringers (which are the supports for the tread and riser) are installed between floor levels. There are several forms of stringers classed according to the method of attaching the risers and treads. The different types are cleated, cut, built-up, and rabbeted.

Review Questions
1. What are stringers, risers, and treads?
2. Name the four types of stringers.
3. When is a center or third stringer used?
4. How is the rise figured when designing a stairway?
5. What is the carriage of a staircase?