A COLONIAL STAIRWAY OF THIS TYPE OFFERS AN ESPECIALLY PLEASING APPEARANCE FROM THE ENTRANCE

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

STAIR BUILDING

DESIGN AND CONSTRUCTION
BEVELS AND FACE MOLDS
SELF-HELP QUESTIONS

BY

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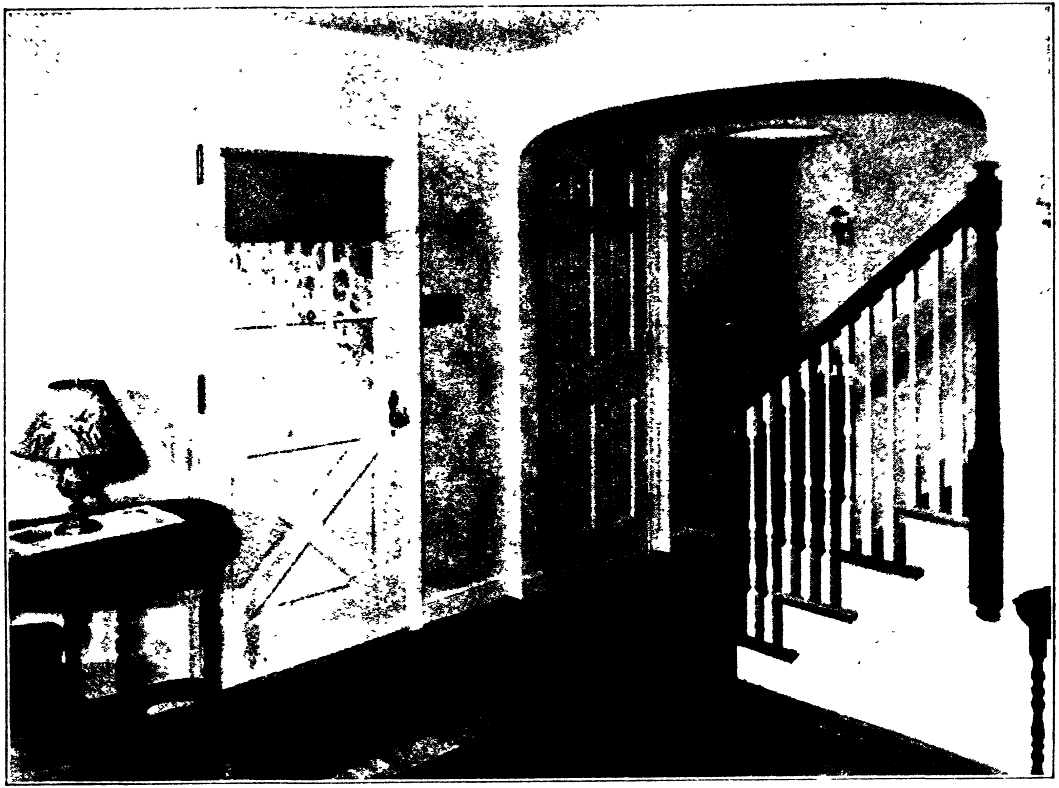
INTRODUCTION

The art of stairbuilding is almost as old as the art of building; for as soon as the efforts of man to provide himself with a dwelling resulted in the development of buildings of more than one story, he was faced with the problem of designing and building stairs in order to gain access to the upper or lower floors. Experience has resulted in the development of certain methods and rules for the laying out and building of stairs, rules which have come to be accepted among craftsmen and designers as standard. Observance of these rules will result in stairs which are easy and safe to use, and which are strong and durable. It is equally true that disregard of these rules and methods will result in the construction of stairs which are inconvenient, perhaps unsafe to use, and which may be of short life. In the following pages an attempt is made to explain these rules and methods.



AN INTERESTING STAIRWAY WHERE LITTLE SPACE IS AVAILABLE

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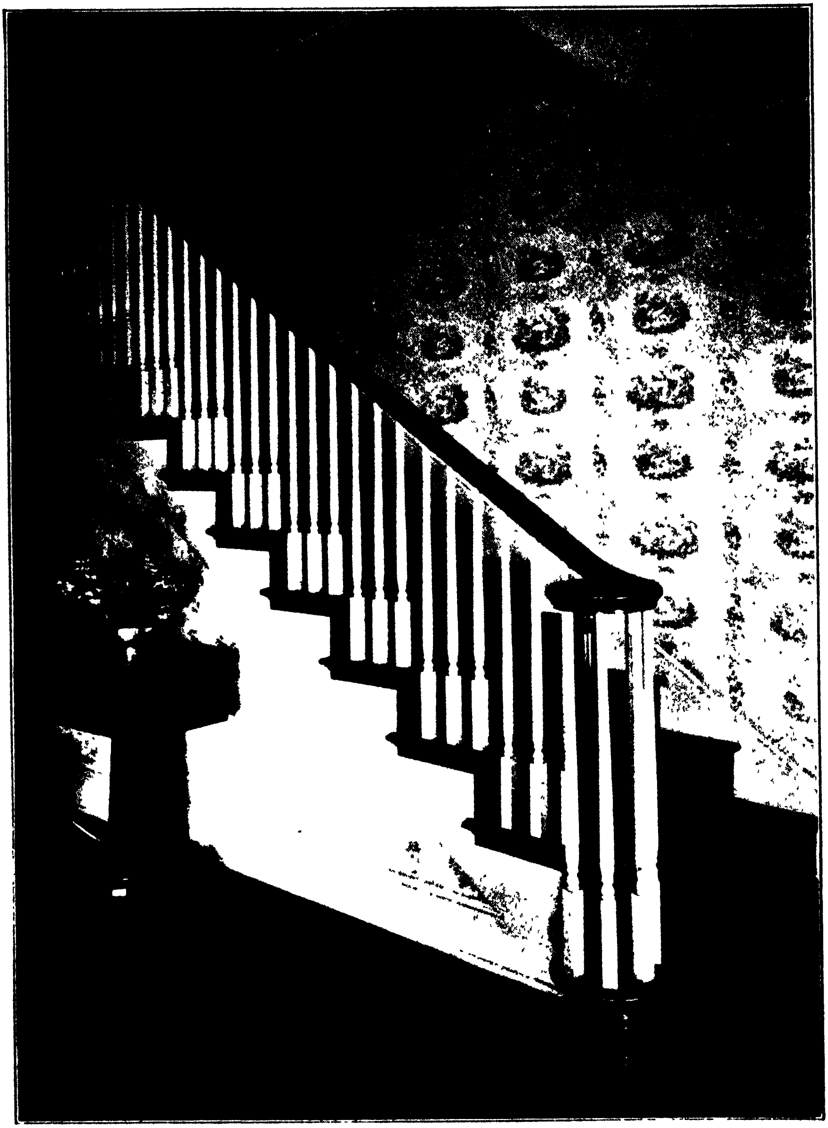
CONTENTS



THE BEAUTY OF THIS STAIRWAY IS A RESULT OF CORRECT DESIGN AND PROPORTION OF THE SEVERAL PARTS

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STAIR BUILDING

CHAPTER I

TYPES OF STAIRS AND THEIR LOCATION

Types of Stairs. A number of types of stairs have been developed and used, ranging from the simplest to some very elaborate ones, and before proceeding to a consideration of how to build them,

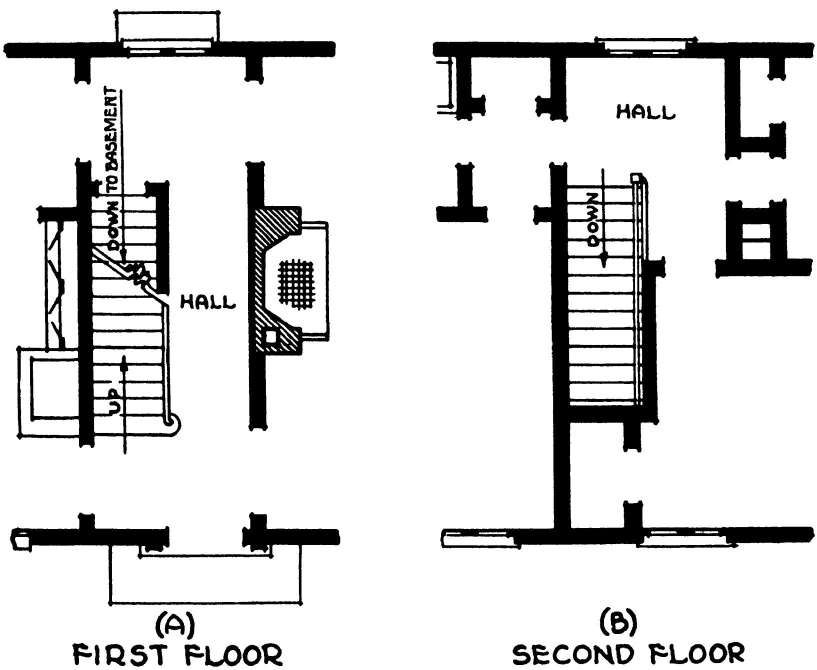

Fig. 1. Plan of Open String Stairs

some of these types will be illustrated and the names by which they are generally known in the trade will be given.

The cheapest and simplest type is what is called the *straight stair* or the *straight run stair* which derives its name from the fact that the stair leads straight up from one floor to the next without any turns or landings. Fig. 1 shows this type of stair in plan. As there are no landings, there will be at least 13 or 14 steps to climb without a break or rest, which makes the use of this type somewhat tiring.

Straight stairs may be built with a wall on each side as shown in Fig. 2, in which case they are called *close string* stairs; or they may have a wall on one side only, as shown in Fig. 1, when they are generally called *open string stairs* and have one side open to the room or hallway so that a hand-rail or balustrade is necessary at the open side of the stairs, with posts at top and bottom called *newel posts.*

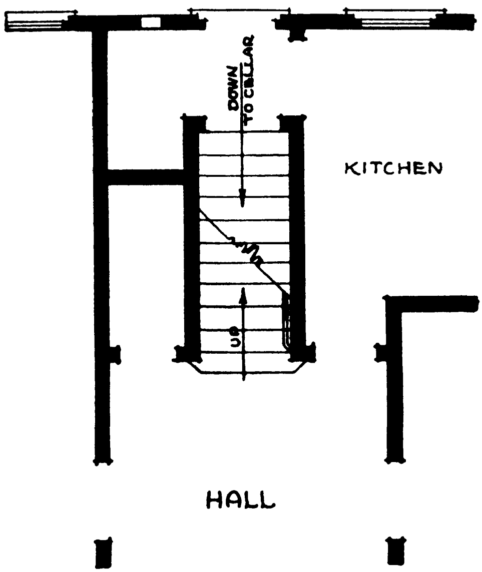

Fig. 2. Plan of Close String Stairs

Straight stairs require a rather long hallway, which is sometimes a disadvantage, especially in a small house.

In order to reduce the length of the space occupied by the staircase or to make the stair easier to use by providing a place on which to pause and rest, a platform or landing is often introduced at some point in the run of the stair and usually the stair takes a turn at this point. Sometimes the stair is an open string stair at the bottom and changes, after mounting a few steps, to a close string stair, as shown in Figs. 3, 4, and 6. These figures also show a short length of balustrade with a newel post at the bottom.

The number and location of landings determine the name of the stairs. When the landing is near the top or near the bottom of the staircase, that is, near the upper or the lower floor so that there are only a few steps between the landing and the nearest floor level, the stair is called a *long* **L** stair or a *quarter space stair* because the plan of the stairs is **L**-shaped and because, in going up, the climber turns

Fig. 3. Open String Stair Which Changes to Close String

one-quarter of the way around, or at an angle of 90°, and so faces a different way at the top than he was facing when he started up. Fig. 4 shows a stair of this type with the landing near the top, while Figs. 5 and 6 show stairs with the landing near the bottom. Such stairs are sometimes called *dog-legged* stairs or *platform* stairs.

Fig. 7 shows a stair with two turns, one near the top and one near the bottom; this type is known as a *double* **L** stair.

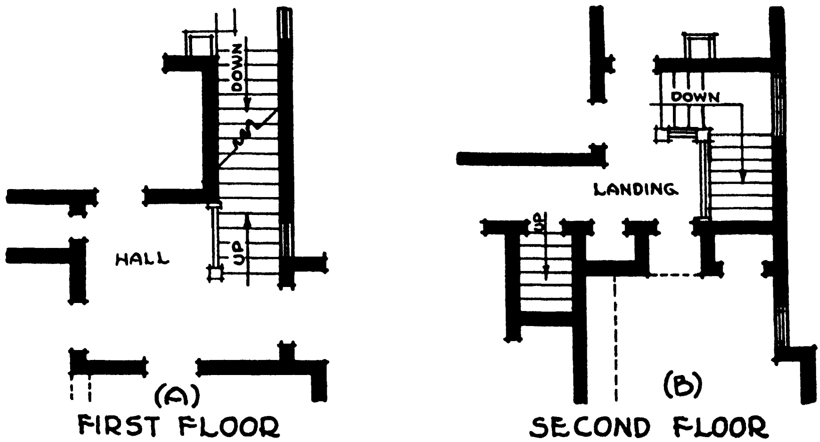

Fig. 4. Plan of Stair Starting as Open String and Changing to Close String, with Landing Near Top

If the landing is placed near the center of the flight about half way between the two floors, as shown in Fig. 8, the stair is called a *wide* **L** stair.

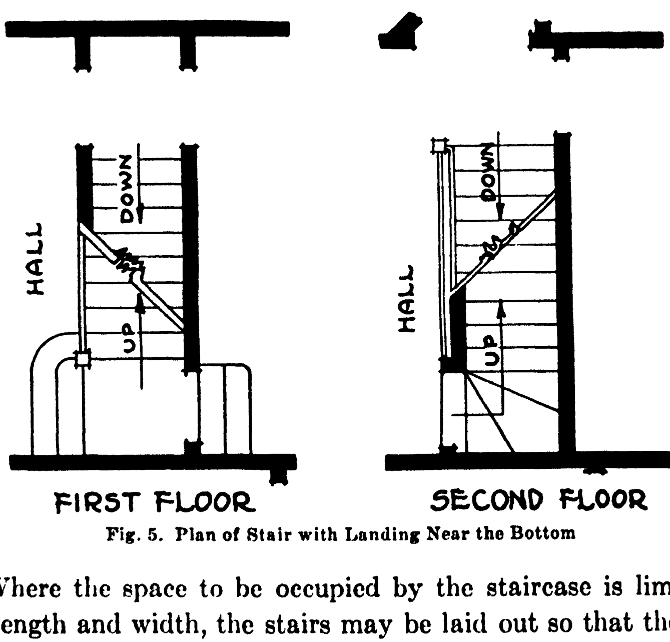

Fig. 5. Plan of Stair with Landing Near the Bottom

Where the space to be occupied by the staircase is limited in both length and width, the stairs may be laid out so that the lower

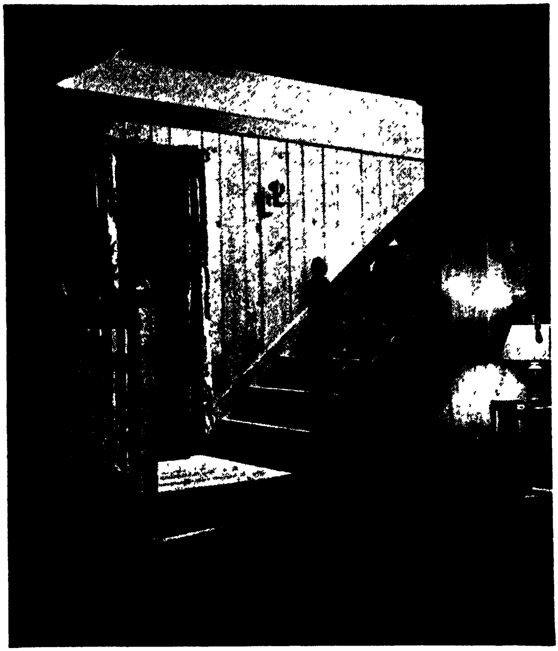

Fig 6. Platform Stair

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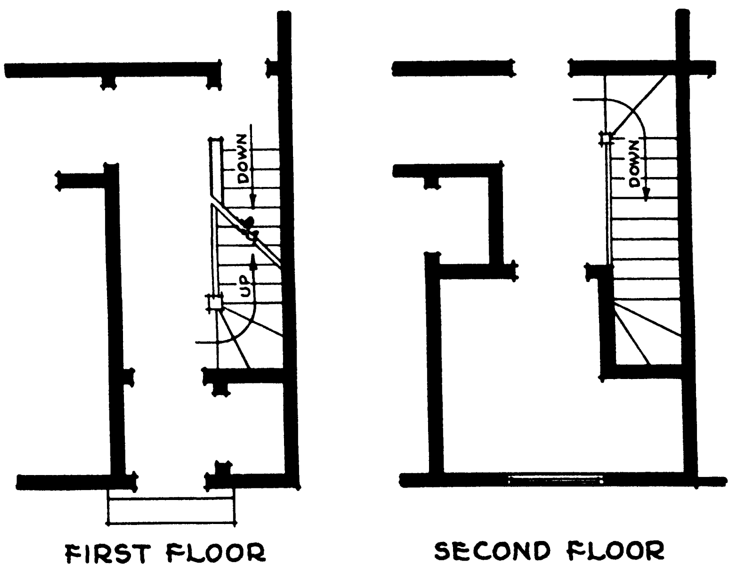

Fig. 7. Plan of Stair with Two Turns (Double L Stair)

part will go up to a landing which is at least twice the width of the stairs and located at some intermediate point between the floor levels. From this landing the stair will "return on itself" and the second flight of stairs will continue up from the landing in a direction opposite to the direction of the first flight, as shown in Figs. 9 and 33. For best results the landing should be at about the middle of

Fig. 8. Stair with Landing about Midway between First and Second Floor (Wide L Stair)

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the staircase so that there will be about the same number of steps in each of the two flights of stairs, but this need not be so. A stair of this sort, where the two flights are close to each other with very little space between, is called a *narrow* **U** stair or a *platform stair returning on itself*, or a *half-space stair.*

Where space and cost limitations will allow of it, a staircase which presents a much better appearance can be laid out using two landings with a short flight of steps between them as shown in Fig. 64. This type is called a *wide* **U** or an *open newel* stair, and the small space enclosed on three sides by the three flights is called a *wellhole.*

Space limitations often make it difficult to "work in" a stair with landings, and in this case a device is frequently resorted to which is quite common practice but is to be avoided if possible. This device consists in introducing into the stair, at the turns, steps called *winders,* which are very wide at the outside and very narrow or even of no width at all at the inside, so that in making the turn a person is also ascending or descending the stair. To put it another

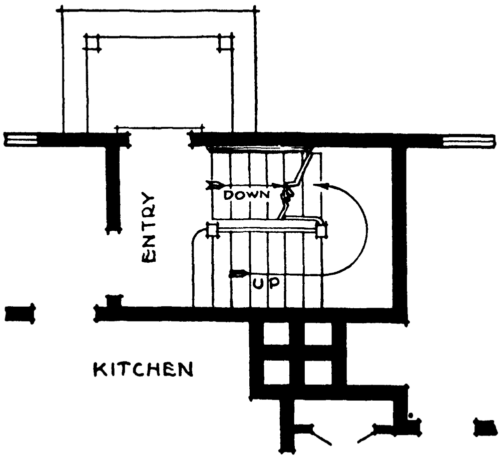


Fig. 9 Plan of Stair Which Returns on Itself (Narrow U Stair)

way, it might be said that the usual landing space is divided into two or three small three-sided landings. This is illustrated in Figs. 5 and 7. To distinguish them from the winders, the ordinary straight steps are sometimes called *flyers.*

The principal objection to the use of winders in staircases is that at the inner corner where all the winders meet, there is very little, if any, width of tread left to support one's foot. Also, the risers are of the normal height and all come together at this point, which makes a very steep descent at the corner. This is considered to be more or less dangerous, as it may be the cause of a bad fall.

One rule is that the narrowest part of the tread of a winder, which comes at the inside of the turn, should not be less than three quarters of the width of an ordinary stair tread. This rule is seldom observed, as it is impossible to do it at a square turn. An attempt to approach this requirement results in what is known as a *geometrical stair,* an example of which is shown in Fig. 10. A staircase of

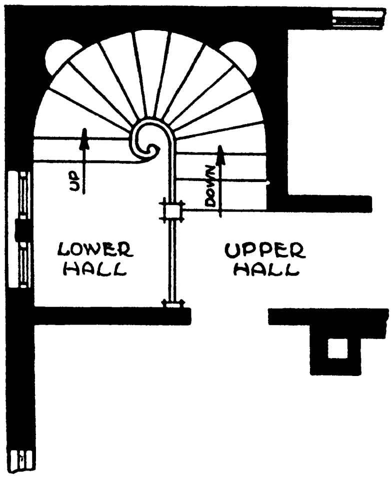


Fig. 10 Plan of Geometrical Stair

this kind has no newel posts at the turn of the stairs, but has the balustrade or handrail following the curve.

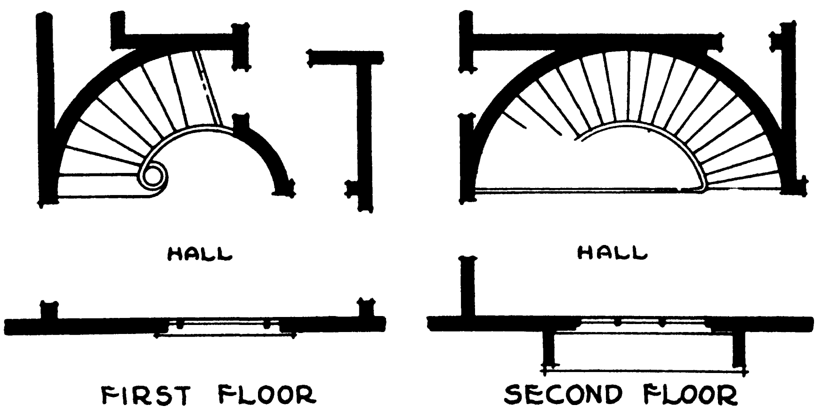


Fig. 11. Plan of Winding Stair

The idea of the geometrical stair is a very old one and has been developed to produce what are known as *winding* stairs which have very wide wellholes, as shown in Fig. 11.

A very elaborate winding stair is shown in Fig. 12. In order that the treads may be practically the same width throughout their entire length and thus avoid the undesirable effect of winders, the risers in

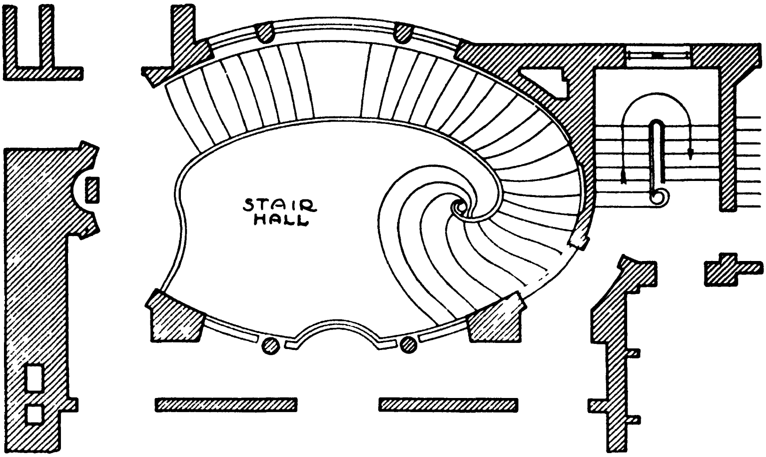


Fig. 12. Plan of Elaborate Winding Stair Having Dancing Winders

this stair are curved as shown and do not converge to one point. Such steps are called *dancing* winders.

Geometrical stairs without landings are open to the same objec-

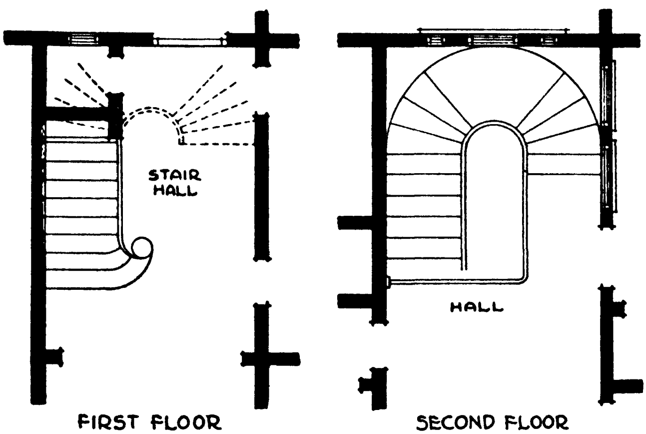


Fig 13. Plan of Geometrical Stair with Landing

tion as long straight flights of stairs: they may be tiring because they afford no opportunity for a pause in the ascent. For this reason a landing may be introduced at the end of the wellhole as shown in Fig. 13.

Choosing the Location for the Stair. Some consideration should be given here to the question of planning for the stairs, that is, of choosing the most suitable location for them. There are a number of factors which have a bearing on the proper location for the stairs in any plan. The first four factors have to do with the stairs themselves and they are as follows:

1. Cost of construction of the staircase
2. Design of the stairs as regards available space for the staircase in the plan
3. Design of the stairs as regards convenience and safety
4. Appearance of the staircase

The next three factors have to do with the affect of the location of the stairs on the other parts of the plan and they are as follows:

5. Convenience of access to the stairs, both on the lower floor and on the upper floor
6. Location of stairs as regards light and exposure
7. The question as to whether the stairs are to be made a decorative feature in the building and therefore put in a prominent location or whether they are to be kept out of the way

As regards Item 1, it can be said that the cheapest stair to build is the straight stair, which is one without turns, landings, or winders, such as that shown in Fig. 1 and if it is located in such a position that it has a wall or partition on each side of the flight, it will become still cheaper because the partitions can be depended upon for support, thereby lightening the strings. Moreover, the balustrade can be replaced by a simple handrail supported by brackets on the enclosing walls. A stair of this kind is shown in Fig. 2 and an example of the handrail on brackets is shown in Fig. 3.

Of course the long straight stair is not an easy stair and it does not make a very good appearance, but it requires the least possible space and in a small plan it can be quite conveniently located. In more spacious and expensive plans, where there can be a front or main staircase and a back stair, the back stair is frequently of this type.

In connection with Item 2, it is evident that in the majority of cases the space available in the plan, after the principal rooms have been located and the size of the building fixed, is so restricted as to size and shape that a straight stair cannot be worked in. It then is necessary to lay out the stairs with a turn either at the top or the bottom, making them **L** shaped, or with a turn at both top and bottom, giving them the form of a double **L**. Very often space will not permit full size landings at these turns, and winders must be introduced in spite of the fact that they are undesirable. At times it is even necessary to fit the stair into a rectangular space in the plan and consequently to have three landings, all of which in the worst cases must have winders as shown in Fig. 14. This is dangerous in case of a fall from the top of the stairs, and for this reason at least one of the landings should be free from winders.

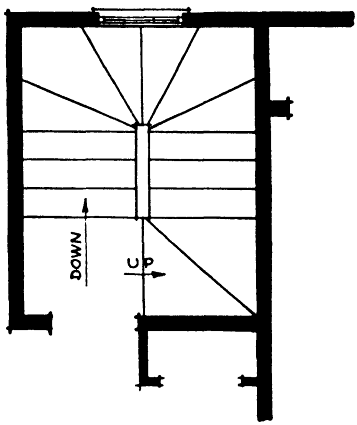


Fig. 14. Plan of a Stair Fitted into a Rectangular Space

Due consideration should also be given to the question of getting furniture up and down the staircase, which becomes very difficult in the case of a narrow stair with winders.

As regards Item 3, the long straight stair without landings is neither the most convenient nor the safest, and a stair with many turns in which there are many winders, or indeed any winders at all, is neither convenient nor safe, although in most stairs of moderate cost there are some winders. Where there is room enough and the cost can be afforded, a staircase of good width with two or preferably with only one generous landing (such as the quarter-space or **L** type or the half-space or **U** type) is to be preferred, but it is not often that space and cost restrictions will permit these types to be used.

In dealing with Item 4, the practical is forsaken for the aesthetic.

Of course, appearance need only be considered when the stairs are so located that they will be seen by guests; it need not be considered in the case of so-called "back" stairs or stairs leading to the attic or the basement. Usually, appearance becomes a factor only in the case of stairs located in the entrance hallway. A stair of good width with spacious landings and of the open newel type obviously looks

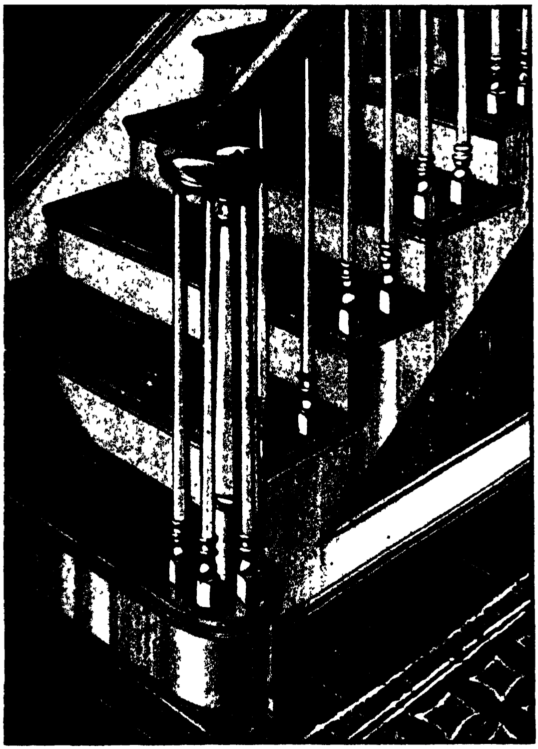


Fig. 15. Colonial Stair
Courtesy of Morgan Company, Oshkosh, Wisconsin

better than a narrow stair with winders, but the wide straight flight such as is frequently seen in old or new colonial houses also presents a good appearance. See Fig. 189.

The design of the newels and balustrade has much to do with the artistic effect of the stair. Fig. 15 shows a very pleasing colonial stair, the various parts of which can be obtained from stock at the mills. Fig. 16 shows an expensive English type seen from the second floor. All parts of this stair are made to order.

Best of all from the point of view of appearance is the geometrical or spiral stair, either circular or elliptical, but this type is usually

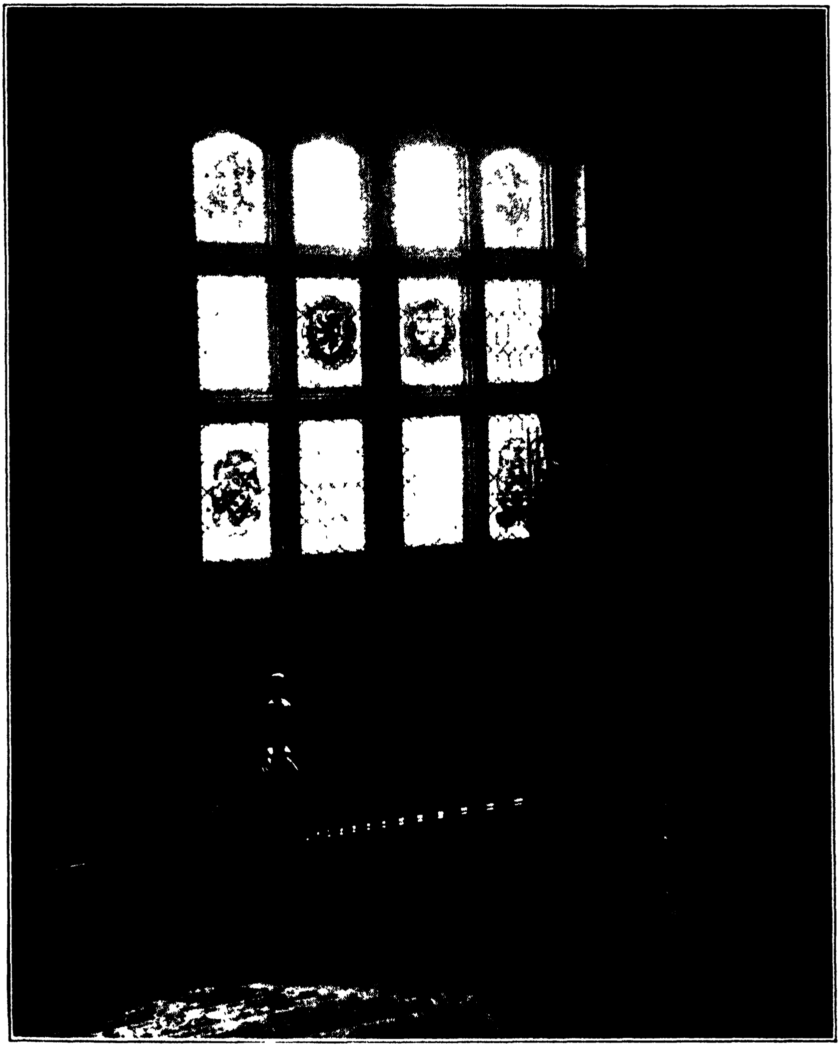


Fig. 16. English Stair, from the Top

seen only in large and expensive mansions or in public buildings.

Leaving the stairs themselves and coming to the question of planning, Item 5 deals with the location of the staircase for easy and convenient access. With this in view most stairs are centrally located and usually start up from the front hall. This arrangement has the advantage that anyone entering can get to the stairs and reach the upper part of the house without passing through other rooms, where there may be guests whom he does not wish to see or to disturb. However, this location usually requires a larger entrance hall than would otherwise be necessary, and the advantage mentioned above is often dispensed with or ignored, and the stairs are made to go up from the living room as shown in Fig. 17. On the upper floor the stairs almost always terminate in the hall, never in a room, because the upper floor rooms are always for private uses, such as bedrooms

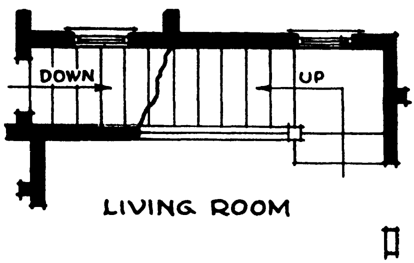


Fig. 17. Plan of Stair Going up from a Living Room

or bathrooms. Occasionally, stairs to seldom-used attics are located in closets off bedrooms, but this is not a desirable arrangement.

In locating the stairs from first to second floor, it must be remembered that space is saved by having the stairs to the basement or cellar go down underneath the main stairs as shown in Fig. 17. To accomplish this, the staircase must be so located that the top of the cellar stairs can easily be reached from the kitchen without having to pass through any other room. See Fig. 2.

Attic stairs are sometimes located to go up over the main stairs, but this usually means that the attic stairs and part of the attic space are exposed to view from the second-floor hall. This requires a more expensive attic stair than is otherwise needed, and it is often desirable, for other reasons, to have the attic stairs enclosed, with a door at the foot. On this account space is often taken on the second floor to provide for a narrow attic stair separate from the stairway of the main stairs, and the second-floor space above the main stairs is left open and unoccupied, with a balustrade along the edge of the second-floor landing overlooking the staircase. An example of this arrangement is shown in Fig. 4. Of course, in very small houses this apparent waste of space is not possible.

Item 6 needs to be considered because the stairs do not require much light or any sunshine, while rooms such as the dining room, living room, and even the kitchen, do need wall space which will give them these things; so the stair may better be placed in a darker location

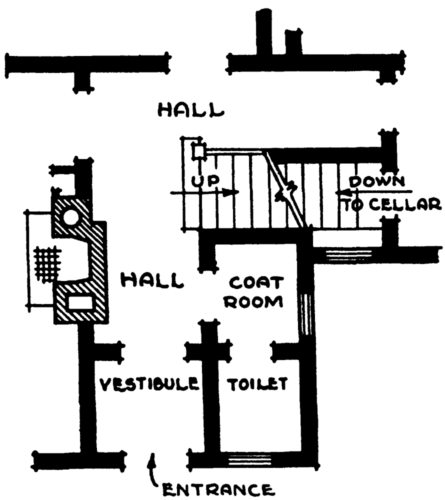


Fig. 18. Stair Partly Concealed from Entrance Doors

away from the sunny side of the house. If it is possible to place them so that they will be lighted by a window, this is very desirable but not absolutely necessary, since artificial light can be used for them and they do not require ventilation.

It is usually cheaper to build the staircase in a corner, utilizing the outside walls for support, as shown in Fig. 10 but this is seldom possible because it places the stair in a position not readily accessible, especially on the upper floor, and as a rule the corners are required for the rooms. In northern climates the stairs may well be located on the north side of the house, while the dining and living rooms should preferably be situated on the east and south sides. In warm southern climates, this condition may be reversed.

Sometimes the stairs are regarded not only as a means of getting from one floor to another, but also as a decorative feature in the design of the interior. Item 7 suggests this condition, and where money is spent on the stairs to make them decorative they are usually so placed that they will be seen and appreciated. This may mean that they will start up out of the entrance hall or the living room, or in large mansions they may be located in a special stair hall off the entrance hall. Under such circumstances, economy need not be considered, and a spacious open newel or spiral staircase may

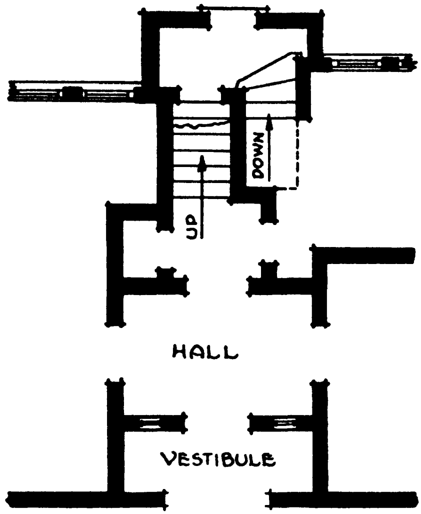


Fig. 19. Plan Showing Stair Placed in an Alcove

be used without regard for space or cost restrictions. Sometimes the stairs are located in an alcove off the main entrance hall or even in an entirely separate stair hall, as shown in Fig. 18, so that they will not be quite so prominent a feature at the entrance as they usually are.

Often the stairs are not regarded as a decorative feature, but as a necessary evil in the interior design; or it may not be desirable to spend enough money to make them decorative. In this case, or for other reasons, they are sometimes placed in a nook or alcove off the entrance hall, but where they cannot be seen directly from the front door or from the entrance to the living room. See Fig. 19.

Cellar Stairs. In these days when oil burners or stokers are often installed or furnaces are gas-fired, the furnace rooms in the more pretentious houses become recreation rooms or play rooms.

The basement is used to such an extent that the basement stair is made like the main stair with simplified newel posts and hand-rails. In the smaller, cheaper type of house, the *cellar stair* is still to be

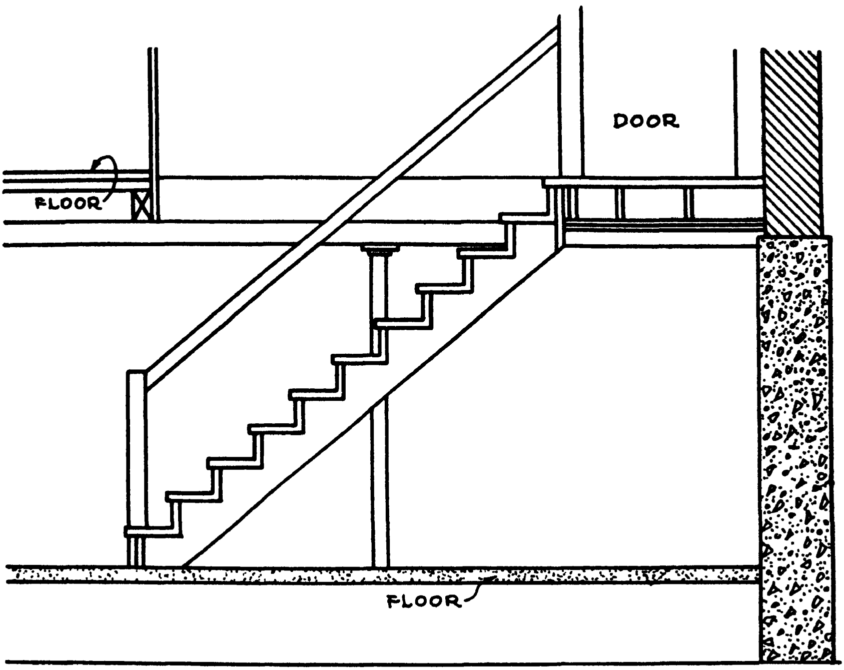
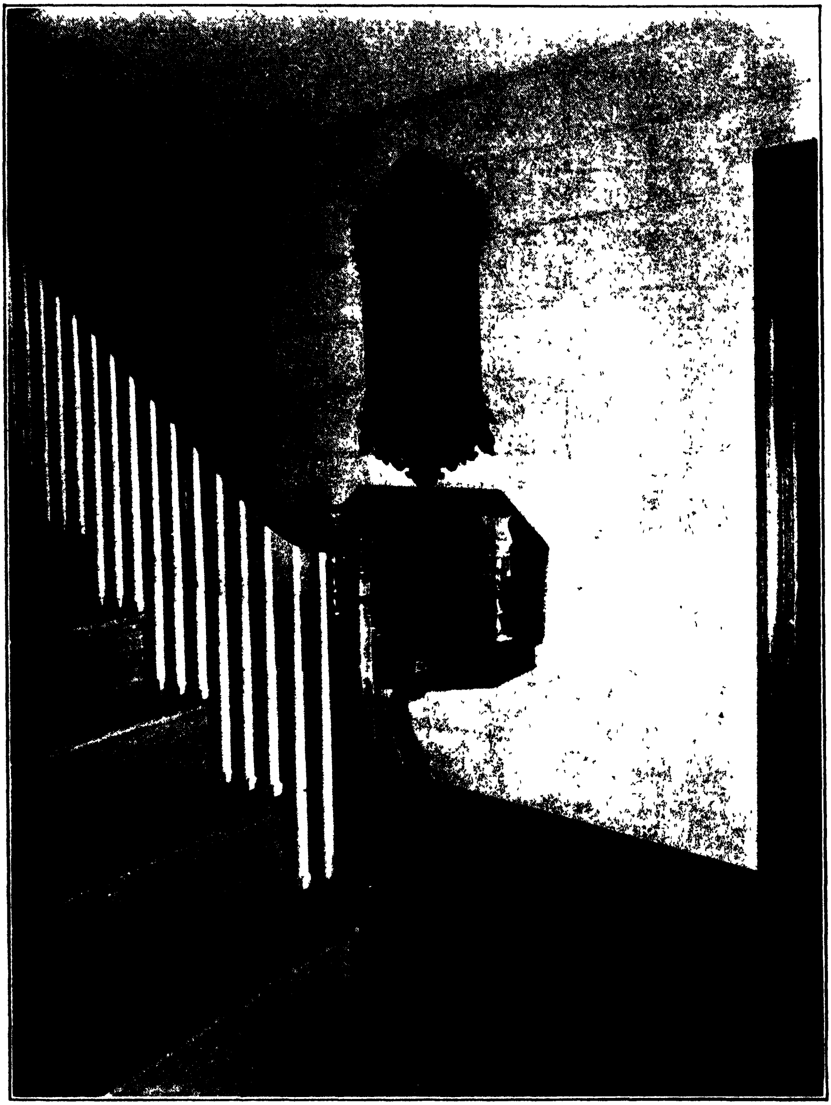


Fig. 20. Typical Cellar Stair

seen. This kind of staircase is quite unadorned, usually built of pine with simple, cut strings and plank treads. Often a cellar stair is without risers and has the plainest sort of small, square, solid newel post and a hand-rail without balusters. As the head room in the cellar is low, the run of the stairs is short, and as a rule it can be a straight run. Fig. 20 shows a flight of cellar stairs which is fairly typical.



AN INTERESTING OPEN STAIRWAY

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CHAPTER II

STAIR CONSTRUCTION

The most essential parts of any staircase are the treads, since it is these which afford a footing, or series of footings, by means of which one can get from one floor or landing to another; the risers may be omitted in a rough stair, but not the treads. However, the

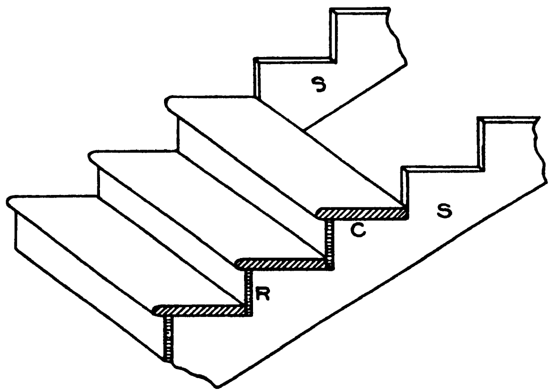


Fig 21. Parts of a Staircase

treads are useless unless they are supported, and this fact leads to a consideration of the strings.

Strings support the treads just as the joists support a floor. Fig. 21 shows a part of a staircase in which *C* is one of the treads, *S* and *S* are the strings, and *R* is one of the risers. A stair may have only two strings as shown, one at each end of the treads; or in a wide stair there may be an additional string in the center of the treads, making three; or in an exceptionally wide stair there might be even more.

Laying Out Strings by Use of Steel Square. In order to properly receive and support both the horizontal treads and the vertical risers, the strings must be cut as shown in Fig. 21. Strings of this sort are called open strings, or sometimes cut strings, because they stand free from any wall or partition and because triangular pieces are cut out of them to receive the treads and risers. The strings which come at the center of the treads (that is, *not* at the sides of the staircase) are called rough strings because they are usually cut from undressed plank. The rough strings are entirely concealed from view and their size depends upon the unsupported length of the string.

In cutting out the triangular or three-sided pieces to accommodate the treads and risers, the steel square will be found very useful. It is applied to the plank as shown in Fig. 22. In this case

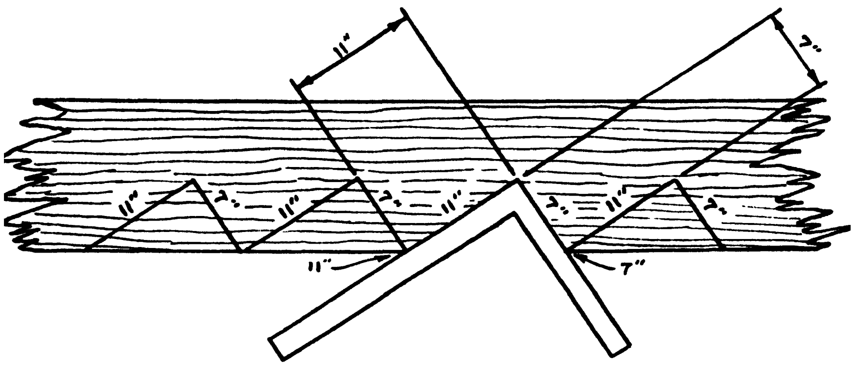


Fig. 22. Steel Square Applied to Cut a String

a width of 11 inches was allowed to receive the tread and a height of 7 inches to receive the riser. The 11-inch mark on the blade and the 7-inch mark on the tongue must both come exactly on the edge of the plank, the edge previously having been dressed for this purpose. A mark is made along the outside edge of the blade and tongue of the square, indicating two sides of the triangular piece which is to be cut out of the plank. The square is then moved along to the next position and another triangle marked out and so on. The way in which the dimensions 11 and 7 are determined will be explained later.

Laying Out Strings by Use of the Pitch-Board. Another method by which the cuts can be marked out on the string is by use of a *pitch-board.* This is a three-cornered template made of sheet metal, or of comparatively thin pine or hard wood, in the shape of a right-angled triangle of which the short side is the height of the riser cut (7 inches in Fig. 22) and the next longer side is the width of the tread cut (11 inches in Fig. 22). The third side is the longest side, or hypotenuse, of the right-angled triangle. If pine is used, it may be ½ inch thick, while if hard wood is employed, ¼ inch may be thick enough.

This template can be cut out of the material with the aid of the steel square as shown in Fig. 22. Applying the square to the dressed edge of the stuff as shown, mark off the three-sided piece and then carefully cut it out. Fig. 23 shows a pitch-board after being cut out. To make it easier to use, a piece of dressed stuff a little wider than the thickness of the pitch-board is nailed or glued on to the longest edge to act as a gauge or fence, such as is used in connection with a steel square. Fig. 24 shows the pitch-board in elevation with the

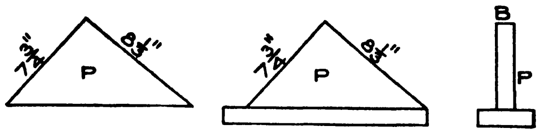


Fig. 23 Fig. 24 Fig. 25

Figs. 23, 24, and 25 Showing How a Pitch-Board Is Made. Fig 23, the Template; Fig. 24, Gauge Fastened to Long Edge; Fig. 25, Sectional Elevation of Completed Pitch-Board

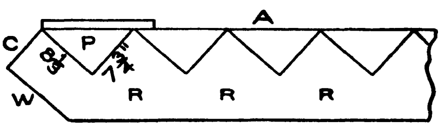


Fig. 26. Method of Using Pitch-Board

gauge or fence attached, and Fig. 25 shows a sectional elevation of it.

Fig. 26 illustrates how the pitch-board can be used. This pitch-board would be used for a very steep attic stair. It is shown applied to the edge of a string, 8⅓″ representing the width of the tread cut and 7¾″ representing the height of the riser cut. The cuts may be marked out using these two dimensions along the edges of the pitch-board and it can then be moved along to mark out the next triangular cut which will have the same dimensions. In this figure *RRR* is the string, *A* is the dressed edge and *P* is the pitch-board. *C* will be the line of the first riser and *W* the edge of the string which will rest on the floor when the stringer is set up in place in the sloping position it will occupy in the building frame.

Framing for the Support of Stair Strings. Fig. 27 shows 3 stringers in a stair frame. At the bottom where the stringers rest on the floor a 2x4 or 2x6 *kick plate* is nailed to the rough or *sub floor,* and the strings are cut to fit over it so that they cannot slide forward

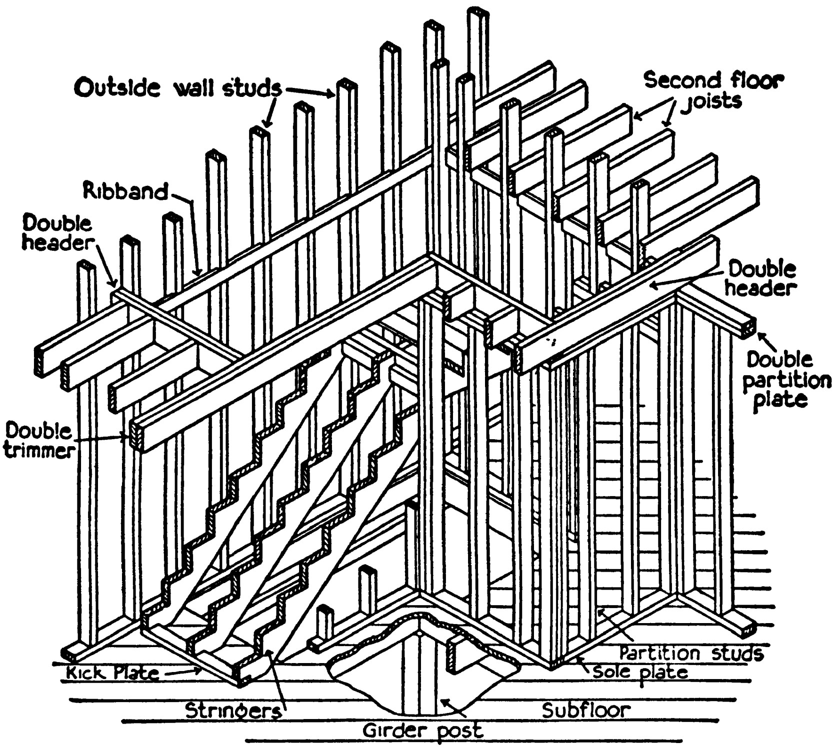


Fig. 27. Framing for Open Stairway
Courtesy of Weyerhaeuser Forest Product.

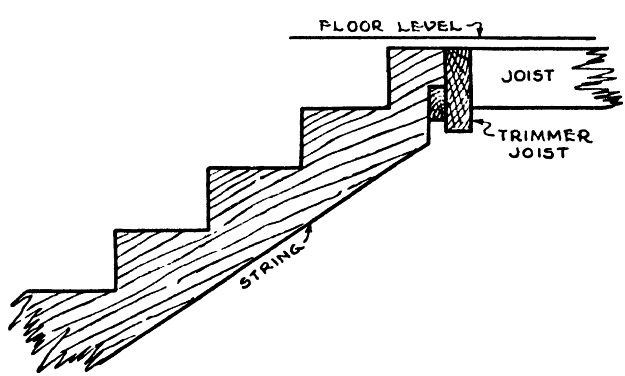


Fig. 28. String Supported at Top by a Scantling Nailed to Trimmer

on the floor. Fig. 27 shows one method of fitting the top of the strings against the floor joists of the landing: the strings are cut over a piece of 2x4 scantling which is nailed to the side of the trimmer joist so that the top of the highest step of the stringer comes flush with the top of the joist as shown in Fig. 28. In Fig. 29 is shown another method of securing the string at the top against the trimmer joist at floor or landing. In this case the trimmer joist is

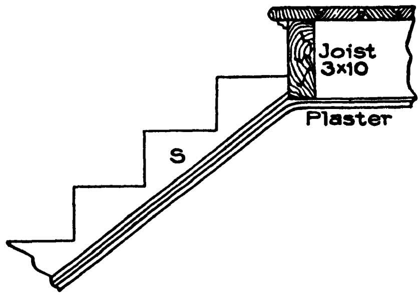


Fig. 29. String Spiked Directly to a Joist at the Top

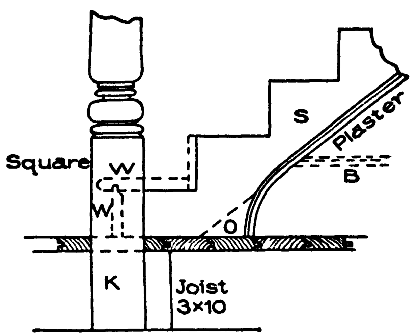


Fig. 30. Showing How a Cut or Open String Is Finished at Foot of Stair

so placed that the joist itself forms the support for the back of the topmost riser. This method of support is evidently not as strong as the method shown in Fig. 28.

Of the 3 stringers shown in Fig. 27, the one on the extreme right will be at the outer side of the staircase. Under it may be built a partition, the studs for which are shown in the figure, and above it would be a balustrade with a newel post at the bottom. Fig. 30 shows such a string at *S* with the newel post shown at *K*. Fig. 31 shows a similar newel post. At Fig. 30 the post is carried down through the rough floor and secured to the side of the 3x10 joist for strength. The newel post is set so that the center of the balustrade and handrail will come at the center line of the newel and this may bring the newel into such a position in relation to the string that the string will have to rest against, or be cut into, the newel post. If necessary, the string may be mortised into the newel post 2 inches.

The newel post must be set very carefully so as to be sure it will

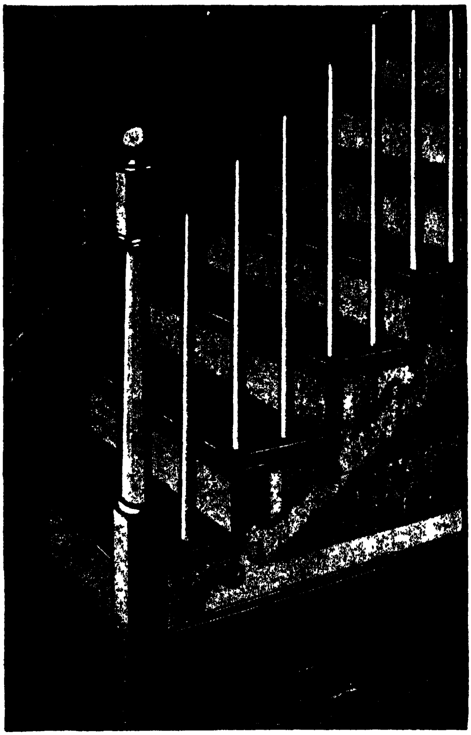


Fig. 31. Showing Relative Positions of Parts in a Finished Stair

Courtesy of Morgan Company, Oshkosh, Wisconsin

line up correctly with the handrail. The bottom tread, which is shown dotted at *W* in Fig. 30, is cut out to fit around the newel post. The bottom riser shown at *W* is cut shorter than the other risers to fit against the newel post. Both the bottom tread and the bottom riser may be mortised into the newel post if desired, but this is unusual. Fig. 32 shows the bottom part of a newel post cut and mortised to receive the string and the bottom tread and riser. The appearance of this construction is illustrated in Figs. 31 and 33.

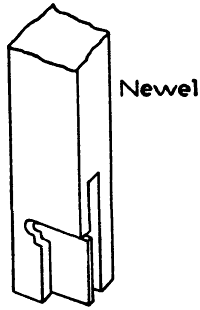


Fig. 32. Newel Cut to Receive Bottom Step

Fig. 33. Platform Stair Returning on Itself (Narrow U Stair)

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

Fig. 34 shows a string at *SS* and illustrates how the risers and treads are usually put together and secured in place. The treads are shown in section at *T* and the risers at *R*. The risers are tongued into a groove cut in the underside of the tread. Fig. 35 shows a larger section through the treads and risers and shows the riser tongued into the tread. Fig. 36 shows a section of the riser alone, with the tongue cut at the top while Fig. 37 shows the tread alone, in section, with the groove to receive the riser cut in the under side. Fig. 36 shows also a groove cut in the riser near the bottom to receive

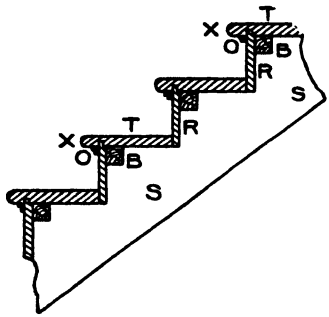


Fig 34. Common Method of Joining Risers and Treads

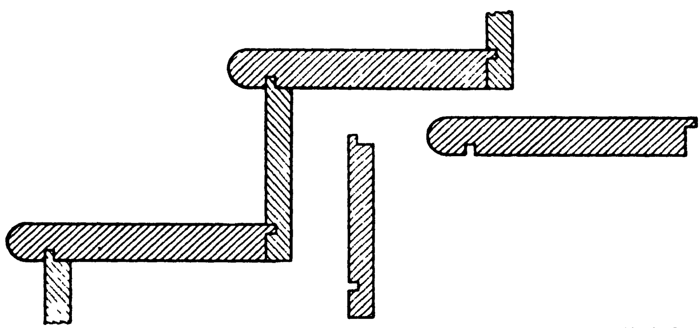


Fig. 35 Vertical Section of Stair Steps

Fig. 36 End Section of Riser

Fig. 37. End Section of Tread

a tongue on the back edge of the tread and Fig. 37 shows this tongue cut on the tread. This gives extra strength to the stair, but is not absolutely essential. Fig. 34 shows the steps without it. The tongues are usually about ⅜-inch long and ½-inch thick. The boards from which the risers are to be cut must be enough wider than the riser (from top to bottom) to allow for the projecting tongue. If they are a little too wide there is no reason why they should not stick down below the underside of the tread except where they cross the strings.

At *B* in Fig. 34 are shown blocks which are glued up tight into the angle underneath the tread and back of the riser. These blocks are from 4 to 6 inches long and from 1 to 2 inches square, made of very dry wood and are placed about 1 foot apart. They are first warmed, then coated with strong glue on 2 adjoining sides, put in place, and nailed securely to both the underside of the tread and the back of the riser.

In Fig. 34 it will be seen that the treads, *T*, project considerably beyond the line of the riser in each case and that the edges of the treads are rounded as shown at *X*. These projecting parts are called *nosings*. When the nosings project well beyond the riser line, cove moldings are placed underneath the nosings and against the face of

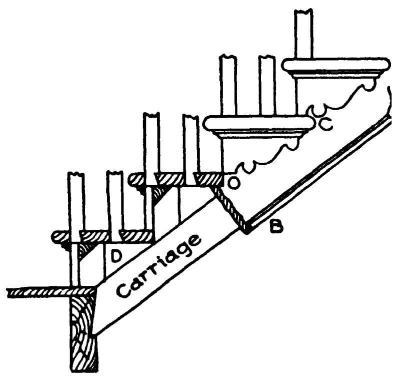


Fig. 38 End Portion of Cut and Mitered String with Part Removed to Show Carriage

the risers as shown at *O*. These moldings are often omitted as shown in Fig. 35, but they add considerably to the appearance of a fine staircase as shown in Fig. 3.

Construction Using Carriages and Blocks. The outside string (the stringer at the right in Fig. 27) is sometimes made like an ordinary floor joist as shown in Fig. 38, and not cut out for the treads and risers. In this case it is called a *carriage*. Triangle-shaped blocks, *D* in the figure, are nailed in place on top of the carriage and they support the back part of the stair treads, while the risers themselves support the front of the treads. This is obviously not so strong a method of construction as the use of the cut string, since the risers may be kicked out of place at the bottom, but they may be well braced by means of three-sided blocks at the top in the angle between the backs of the risers and the undersides of the treads as shown in Fig. 38. This figure shows the carriage framed into the side of the trimming joist at the foot of the staircase. This again is not so strong a method of construction as is that shown in Figs. 30 and 27, where the string rests squarely on top of the floor framing. In the course of time, due to shrinkage of the timbers and loosening of the nails, the carriage might work loose from its support against the trimmer joist and the stair frame would then collapse at this point.

When the end string is constructed as shown in Fig. 38, a cut, *finished string* is nailed or otherwise secured to the rough carriage

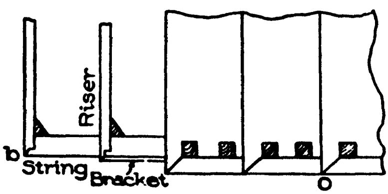


Fig. 39. Plan of Portion of Stair Showing Framing

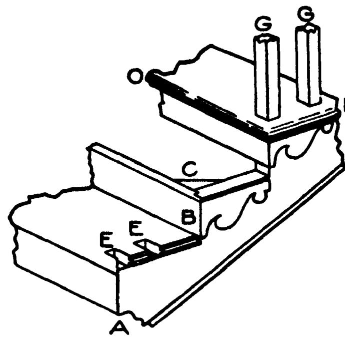


Fig. 40. Portion of a Cut and Mitered String, Showing Method of Constructing Stairs

as shown at *B* in the figure. This finished string is cut from thinner and finer stuff than is the rough carriage, and of course it is dressed and is often finished with a bead or molding at the bottom as shown at *B*. It is cut or shaped to receive the tread and riser. The tread rests squarely on top of it, but where the riser and the string come together as shown in a plan view at *b* in Fig. 39, both the end of the riser and the front of the finished string are mitered as shown, so that no joint will show either on the side of the finished string or on the front of the riser. This is called a *cut and mitered* string. The joint between the end of the riser and the finished string is strengthened by a three-sided block glued snugly into place against the back of the riser and the back of the finished string as shown in Fig. 39 and at *C* in Fig. 40.

Balusters. Fig. 40 at *E* shows how the balusters are dovetailed into the ends of the treads, one baluster on each tread lining up with the face of the riser below, and the second baluster being placed at the center of the tread width. These balusters are shown at *G* in Fig. 40 and in plan in Fig. 39. At *E* in Fig. 40 are shown the mortises cut out of the tread to receive the dovetails which are cut on the lower ends of the balusters. The dovetailing of the balusters into the tread is further illustrated by Fig. 41, which shows three balusters to each tread instead of two.

Fig. 39 shows at *O* how the treads are made wide enough to

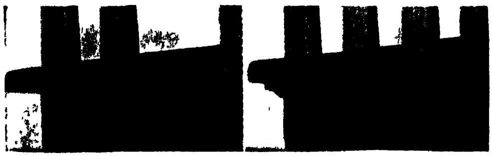


Fig. 41. Sturdy Balustrade Made by Dovetailing the Balusters to the Treads. No Toenailing Is Necessary. Dovetailing Is Concealed by Nosing Which Is Mitered to Fit Front Nosing of the Tread

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

project a distance beyond the face of the finished string equal to the projection of the nosing beyond the face of the riser and then cut or mitered back to line up with the face of the finished string and the face of the balusters. After the balusters are either glued or nailed in place, a piece of stuff molded to match the nosing, mitered at one end and with the molding returned on itself at the other end, is inserted across the end of each riser as shown in plan at *O* in Fig. 39 and also in Fig. 41. This is called a *return nosing.*

Scroll Brackets. In order to give a more finished appearance to the string, shaped *brackets* sawed out of thin, dressed stuff about 3/8 inch thick are nailed, or as it is called, *planted* onto the face of the finished string underneath the return nosings at the ends of the treads and in line with the risers against the ends of which the brackets are mitered as shown in plan in Fig. 39. These brackets are shown in elevation at *O* in Fig. 38 and also in Fig. 31. They are sometimes called *scroll brackets.* When brackets are employed and mitered with the risers, the risers must be made long enough so as to project 3/8 inch beyond the face of the finished string. The upper part of the bracket should fit under the cove molding, or snugly against the underside of the return nosing if the return nosing and the return cove molding are all in one piece.

The tread should project over the face of the finished string far enough to allow for the 3/8-inch thickness of the bracket so that the return cove molding and nosing can fit snugly against the end of the tread and the face of the bracket as shown in Figs. 38 and 40. Great care must be taken about this point or endless trouble will follow.

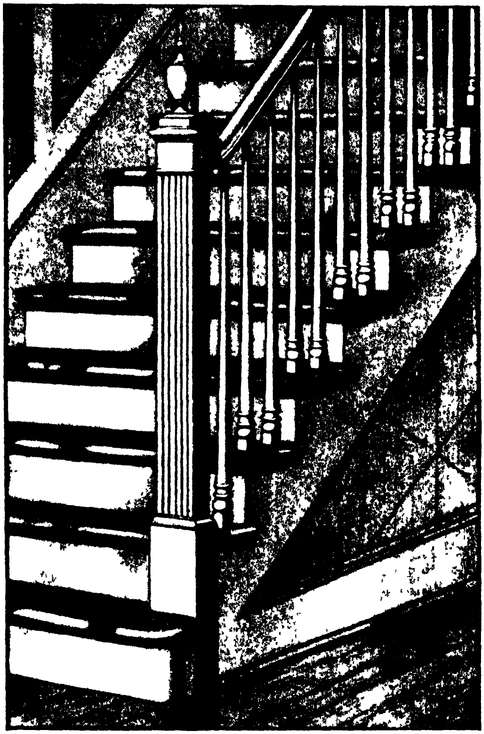


Fig. 42. Finished Stair Showing String without Brackets

Courtesy of Morgan Company, Oshkosh, Wisconsin

Figs. 41 and 42 show a finished string with return nosing but without the brackets.

Return Nosing. This return nosing which is shown in Fig. 41 is cut separate from the tread, is mitered against it and is tacked in place against the end of the tread so that it can be removed on the job to allow for the insertion of the balusters into the slots cut for them in the ends of the treads. After the balusters are put in place, the return nosing is glued solidly into place.

Finish for One-Piece String. In some open string stairs the outside string is made in one piece instead of being a combination of a rough concealed stringer or carriage with a separate finished string attached to it. In such a case it is of dressed finishing wood and is heavier than the finished string already described, since it acts as both supporting stringer and finished string. It would be 1⅛-inches or more in thickness and would be cut to receive the treads and risers. Such a string is shown in plan at *OS* in Fig. 43, in which *RS* is the rough center stringer and *WS* is the wall string. The outside string

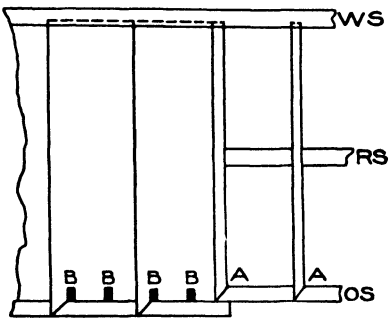


Fig. 43. Part of Plan of Stair with Center String and with Outside String Mitered to Ends of Risers

OS, in addition to being cut out to receive the risers, has the vertical faces of the cuts mitered to match the mitered ends of the risers as shown at *A* in Fig. 43. This figure should be compared with Fig. 39. Both figures show the treads cut off flush with the outer face of the finished outside string, or with the bracket, except for the front edge which projects beyond the face of the riser and the balusters, *B* Fig. 43, and is cut long enough to miter with the return nosing. A careful examination of Fig. 40 with a magnifying glass shows the end of the tread at *EE* cut with a tongue which would fit into a groove in the return nosing. This makes a strong job but is seldom done.

Stair with Housed String. Often staircases are constructed in such a way that the ends of the treads and risers do not show; instead, the foot of the balusters rest on an inclined surface which is the top of the finished string as shown in Fig. 33. In this case a person looking at the side of the staircase does not see the ends of the treads and risers at all, but sees only the finished string. A stair of this kind is called a closed string stair as distinguished from the type shown in Figs. 31 and 42, which are open string stairs. The string is called a *housed string* because horizontal and vertical grooves are usually cut in the inside of the string to receive the treads and risers, as shown in Figs. 44 and 45, while the outside of the string may be

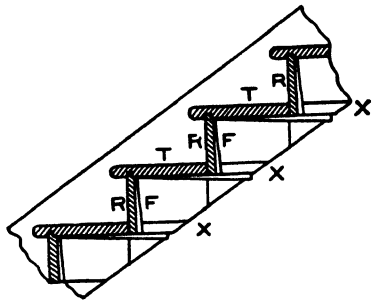


Fig. 44. Method of Housing Treads and Risers

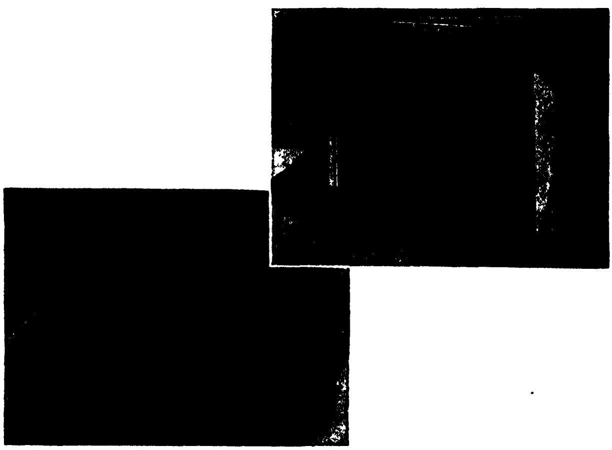


Fig. 45. At Left, String Housed Out to Receive Treads and Risers. Note that Housing Is Rounded to Fit Nosing of Treads. At Right, Wedges Driven into Housing Hold Treads and Risers Firmly without Nails. Risers May Be Tongued and Grooved to Tread Above, and Plowed for Tongue of Tread Below. See Fig. 35.

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

molded at the top and bottom edges as shown in Fig. 46. Such a string is usually about 12 inches wide and 1½ inches thick. In Fig. 44 the treads are shown at *T* and the risers at *R*, while at *F* are shown wedges which are driven into the vertical grooves behind the ends of the risers to hold them securely in place. The grooves are about ½-inch deep and are cut large enough to receive wedges and risers. Wedges are covered with strong glue before being driven into place.

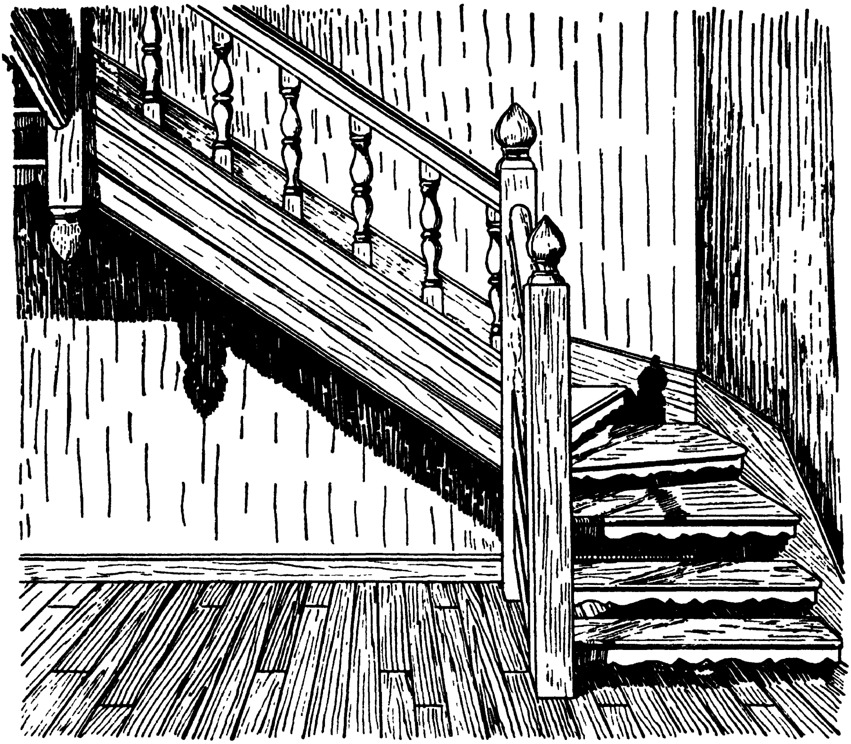


Fig. 46. Stair with Molded Outside String

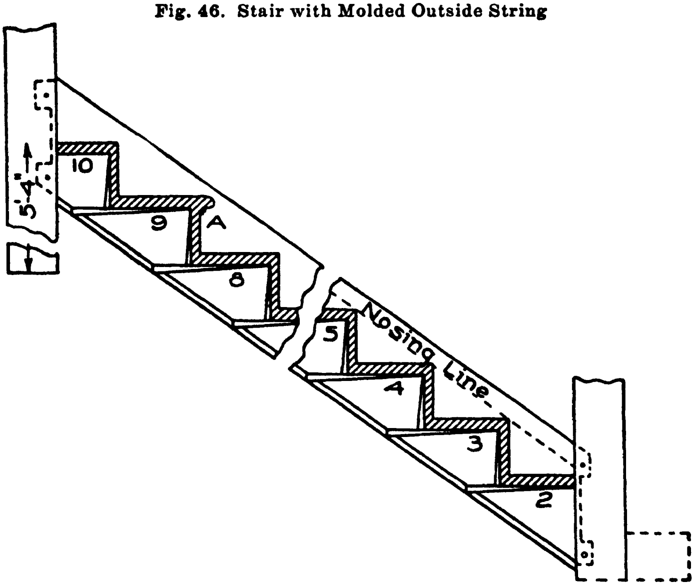


Fig. 47. Method of Connecting Housed String to Newels

At *X* are shown the horizontal wedges which are driven into place underneath the ends of the treads after the vertical wedges have been driven tight. Vertical wedges are cut off flush with the underside of the treads and risers. At the extreme right of Fig. 45

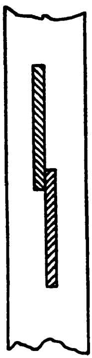


Fig. 48. Mortises in Long Newel for Strings

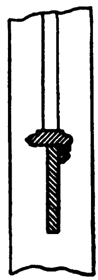


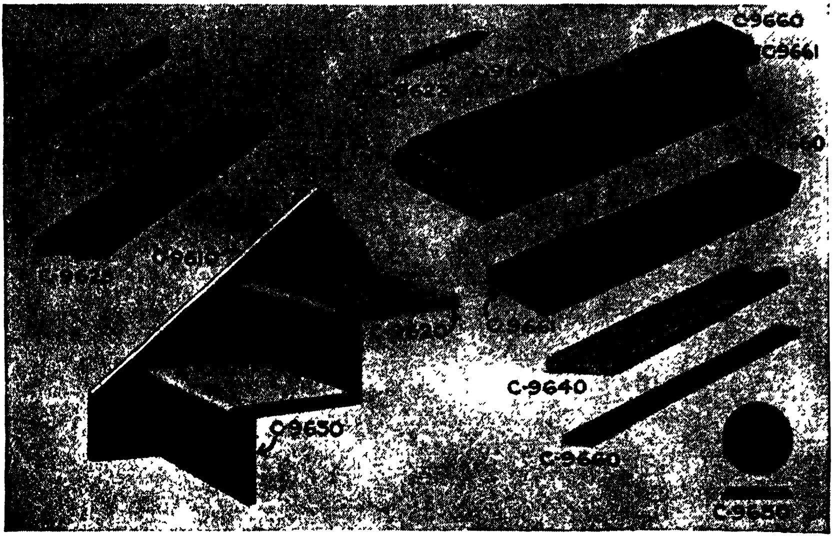
Fig. 49. Mortises in Outside Newel for String, Outside Molding and Cap

is shown a section of the string with the tread housed into it and a cap fitted onto the top of the string.

Fig. 47 is another view of a housed string and shows how the string is usually secured to the newel posts at top and bottom of the flight of stairs. As a rule the ends of the string have double tenons cut on them which fit into mortises cut in the shanks of the newel posts as shown in the figure.

Fig. 48 is a view looking at the side of the newel post at the landing of a stair such as shown in Fig. 33, where the bottom of one string and the top of another are mortised into the newel. In some cases the two mortises would be side by side as shown in Fig. 48, and in other cases the two strings might be in line with each other as indicated in Fig. 33, in which case the two mortises would also be in line and would form one single mortise into which both strings would fit, the top edge of the lower one and the bottom edge of the upper one being cut away so that the two strings fit together.

As shown in Fig. 33 the lower end of the balusters for a closed string stair rest on top of the string and, to receive them, a molded member called a *subrail* or *shoe* is usually planted on the top edge of the string. Fig. 49 shows mortises in an outside newel. Note the section through a finished string with the subrail on the top edge and



Star indicates woods in which items are usually stocked

		W. P. Pine	Yellow Pine	Plain Oak	Unsel. Birch
C-9610	Stringer ¾"x11"	★	★	★	★
	Shipped S4S unless ordered molded to match room base. Order should specify design to be matched.				
C-9620	Tread, 1 1/32"x10½"x3' 5" long	....	★	★	★
C-9620	Tread, 1 1/32"x10½"x3'11" long	....	★	★	★
C-9620	Tread, 1 1/32"x11½"x3' 5" long	....	★	★	★
C-9620	Tread, 1 1/32"x11½"x3'11" long	....	★	★	★
	Treads are nosed front edge. Not tongued or grooved				
	Mitered returns may be had if desired, applied to treads. Dovetailed for Balusters, if so ordered.				
C-9622	Loose Returned Nosing, 1 1/32"x1⅛"x1'4"	....	....	★	★
C-9623	Cove Mold ½"x¾"	★	★	★	★
C-9625	Landing Tread (nosed and rabbeted for 5/16" flooring) 1 1/32"x3½", 3'5" or 3'11"	....	....	★	★
C-9625	Landing Tread	....	★	★	★
C-9630	Riser, ¾"x7½"x3' 5"	★	★	★	★
C-9630	Riser, ¾"x7½"x3'11"	★	★	★	★
C-9630	Riser, ¾"x8 "x3' 5"	★	★	★	★
C-9630	Riser, ¾"x8 "x3'11"	★	★	★	★
	Risers are cut to size but not plowed				
C-9640	Shoe, ¾"x2½"	....	....	....	....
C-9041	Shoe, 1 1/16"x3⅞"	★	....	★	★
C-9650	Rosette, 5" diameter	....	....	....	★
C-9650	Rosette, 6" diameter	....	....	....	★
C-9660	Fillet, ⅜"x1⅜"	....	★	★	★
C-9661	Fillet, ⅜"x1⅝"	★	....	★	★
C-9661	Fillet, 7/16"x2"	★	....	★	★

This stair material is also available in American Walnut

Fig. 50. Miscellaneous Stair Parts

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

a bed mold under the outside of the subrail. Usually a rectangular groove is cut in the top surface of the shoe or subrail just the width of the balusters and running the entire length of the subrail. The lower ends of the balusters are fitted into this groove, being mitered to fit the slope of the string. This leaves open spaces in the groove between the balusters and these spaces are filled up with pieces of hardwood which match the material of the balusters and the subrail,

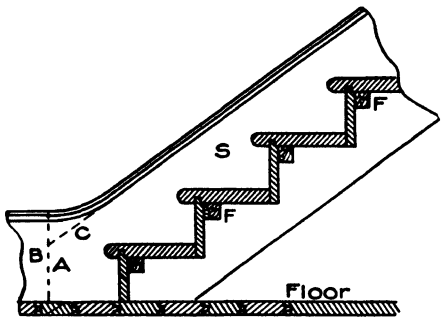


Fig. 51. Showing How Wall String Is Finished at Foot of Stairs

and which are cut to the width of the groove and thick enough to project a little above the top of the subrail and long enough to fit tightly in between the balusters. The top surfaces of these filler pieces may be made of any desired shape, either plain or rounded or molded to suit the fancy of the designer.

The filler pieces are called *fillets*. In order to standardize the millwork, these fillets are themselves often grooved on one side and thus receive the lower ends of balusters which may be of smaller size than the width of the standard groove in the top of the shoe or subrail. In Fig. 50, *C-9641* is a shoe or subrail, *C-9661* is a fillet. *C-9661* is also shown turned upside down and placed in the groove of the shoe *C-9641*, ready to receive a still smaller filler, marked *C-9660* in the figure, which would be set in between the bottom ends of the balusters resting on the fillet *C-9661* in the groove shown. Fig. 50 also shows other items of millwork for stairs which can be purchased from stock, such as treads, risers, landing treads, stringers, and cove moldings.

The wall string *WS* in Fig. 43 is often made a housed string, the treads and the risers being inserted in grooves cut in this string as shown in plan in Fig. 43. This makes it necessary for the wall string to be cut from very wide stuff as shown in Fig. 51, in which *S* is the string. The top edge of the wall string may be plain or it may be molded, as shown, to suit the taste of the designer. At the foot of the stairs a baseboard usually runs around the walls of the hall at the floor and the wall string of the stair is fitted against this base as shown at *A* and *B* in Fig. 51, *B* being the base and *A* the

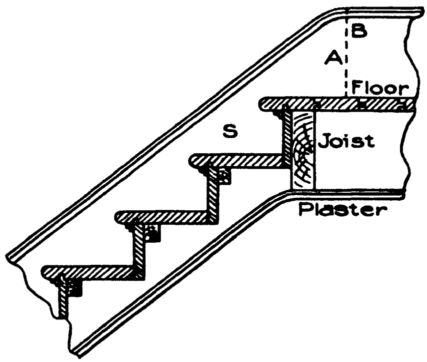


Fig. 52. Showing How Wall String Is Finished at Top of Stairs

stair string. The molding at the top of the stair strings must match the molding at the top of the base. The wall string must have what is called an *easement* or *ease-off*, as shown at *C* in Fig. 51, to make it fit properly against the base. This is accomplished by adding a small triangular piece *BC* to the stair string at this point. Look in the lower left-hand corner of Fig. 8 for an illustration.

Fig. 51 shows the treads and risers of the stair in section and these are fitted into horizontal and vertical grooves in the string and wedged tightly in place as explained before for the outside string and as shown in Fig. 44. Blocks, shown at *F* in Fig. 51, are glued in place in the angle between the backs of the treads and the backs of the risers to strengthen the stairs.

Fig. 52 shows the upper end of the wall string, *S*, at a landing or at an upper floor. The stair string is fitted at *A* to the base *B*, which runs around the landing or around the upper hall. The wall string has an ease-off at the top at *A* to make it fit properly to the base *B*. The string is cut to fit around the floor of the landing and the trimmer joist. This also is illustrated in Fig. 8.

Stair with Winders. Thus far only the strings for *straight* flights of stairs have been dealt with, that is, stairs which extend from floor to floor, or from floor to a landing without a turn. Fig. 53 shows in plan the turn of a stair which is not straight and which has 3

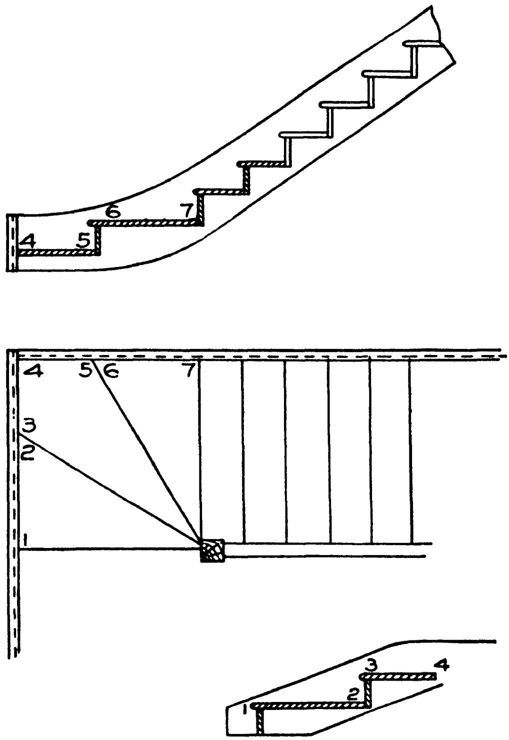


Fig. 53. Elevation and Plan of Dog-Legged Stair Showing Three Winders and Six Flyers

winders at the change of direction instead of a landing. The wall strings shown at *1, 2, 3, 4* and *4, 5, 6, 7* have the treads and risers of the stair housed into them, as indicated by the dotted lines and by the elevation of the strings and sections through the treads and risers. In order to get around the bend, the 3 winders are extraordinarily wide at the wall string as shown at *1, 2, 3, 4* and *4, 5, 6, 7*, while their width is reduced to nothing at the newel post. This widening of the treads at the wall string makes it necessary for the wall string to flatten out at the bottom as shown at *4, 5, 6, 7* of the elevation; the result is a curved string as shown. Fig. 46 is an illustration of a stair with winders at the turn and it shows the modified slope of the wall string.

Bullnose Steps. Fig. 46 shows the newel post at the bottom of a flight of stairs apparently resting on the floor of the lower hall

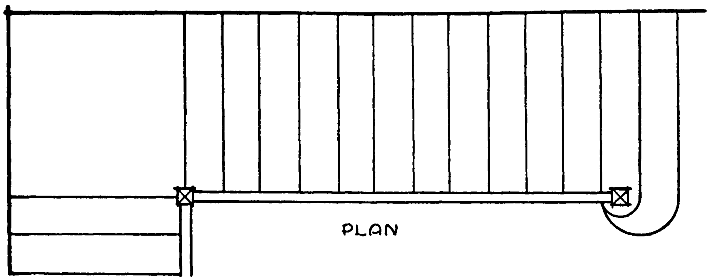


Fig. 54. Plan of Stair with Newel on the Second Stair Tread

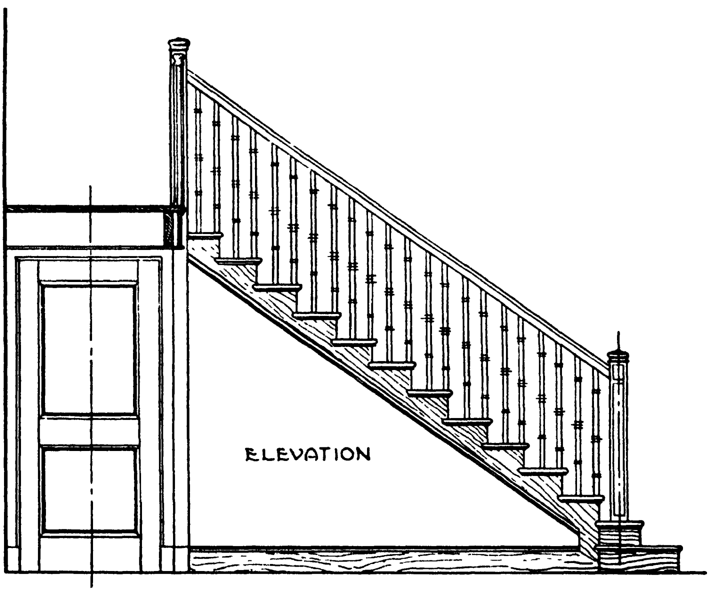


Fig. 55. Elevation of Stair Shown in Plan in Fig. 54

with the tread and riser of the bottom step butting against the inside of the base of the newel post as shown in greater detail in Fig. 30, but often the plainness of this type of stair is relieved by stopping the rail back a couple of steps, as shown in plan and elevation in Figs. 54 and 55, and setting the foot of the bottom newel post up on top of the first or second tread from the bottom as shown in elevation in

Fig. 55. The two steps at the bottom of the stairs extend out beyond and around the base of the newel post, as shown in Fig. 54, and are called *bullnose* steps or *bullnose treads* for this reason. They add greatly to the appearance of the stairs and the stair hall. Sometimes only one step at the foot of the stairs is made a bullnose tread and carried around the base of the newel post, as shown in Fig. 3.

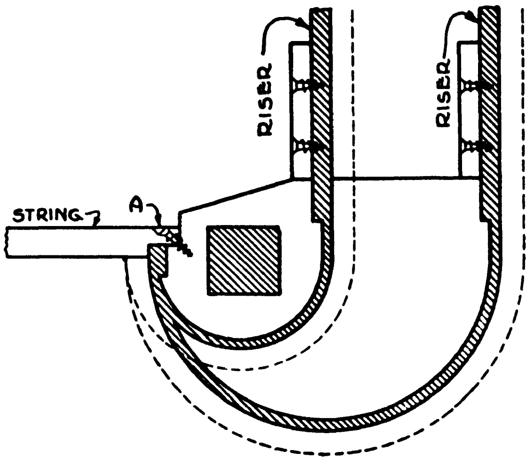


Fig. 56. Plan of Bullnose Steps Showing Construction

The ends of the risers of the bullnose steps seem to bend around in a semicircle (see Figs. 54 and 3) but since it is practically impossible to bend a piece of stuff of the thickness of the ordinary riser to a curve of such a small radius, it becomes necessary to resort to a method involving the employment of a *veneer*, which is a much thinner piece of stuff and can be bent to a small radius. However, if the material of this part of the riser is very thin, it cannot support the tread or itself and must have some sort of solid backing behind it. Partly in order to furnish this solid backing and partly to support the newel post, a solid, built-up block is placed under the newel post as shown in plan in Fig. 56.

This block is built up out of a number of pieces of stuff, each about two inches thick, placed one on top of the other as shown in Figs. 57 and 58, shaped to come under the newel and to form the bullnose curve of the ends of the step as shown in Fig. 56. These pieces are glued securely together to form solid blocks which are set into position at the foot of the stairs as shown in Fig. 58.

The lower end of the outside string is cut with a tenon as shown in Fig. 59 and this tenon is fitted into a mortise cut in the block to receive it and glued solid, thus fixing the position of the block. Moreover, the string is screwed to the block from the back as shown

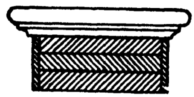


Fig. 57. Section through Bullnose Step Showing Built-up Block

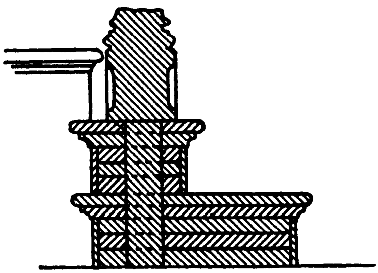


Fig. 58. Vertical Section through Bullnose Steps and Newel Post

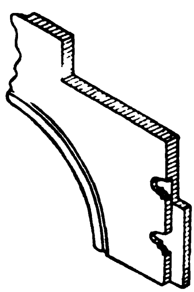


Fig. 59. Lower End of String to Connect with Bullnose Step

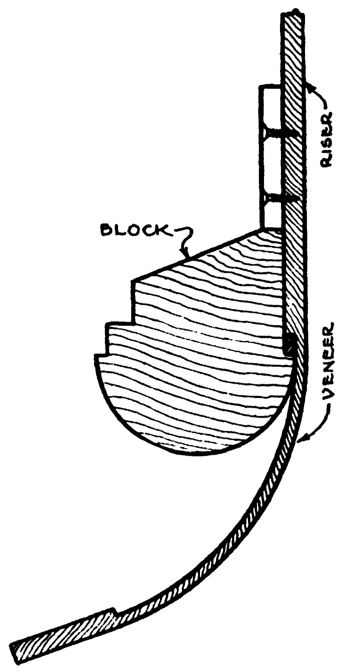


Fig. 60. Veneer, Ready to Be Bent around the Block

in Fig. 56 at *A*. A mortise is cut right through the center of the block as shown in Fig. 58 and into this mortise is inserted a tenon cut on the lower end of the newel post, thus securing the newel post to the block.

To the end of the riser for the bottom step of the stair is glued a piece of the thin veneer as shown in Fig. 60 and this veneer, being flexible, is then bent carefully around and fitted to the bullnose curve of the block as shown in Fig. 56 and secured in place by means of strong glue or concealed screws, or both.

Fig. 61, which is a plan of an L-type or quarter-space stair shows the first step, marked *1* in the figure, designed as a modified form of bullnose, much simpler than the one just described. The bottom riser, in this case, is bent around through a quarter circle and finished against the front of the 6″x6″ bottom newel post. Fig. 62 shows

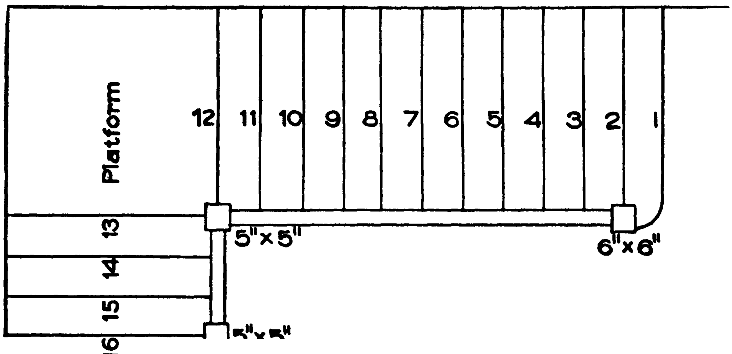


Fig. 61. L-Type Stair with Three Newels and a Platform or Landing

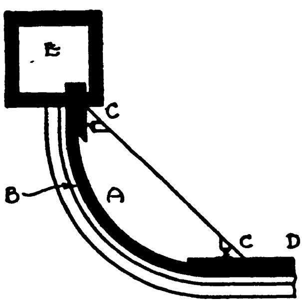


Fig. 62. Bullnose Formed with Veneer and Block

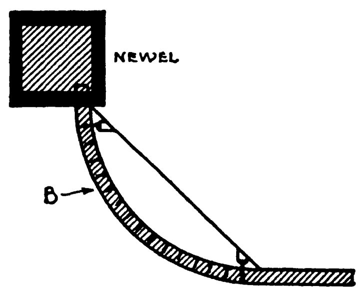


Fig 63 Bullnose Formed by Kerfing the Riser

in plan how this is accomplished by means of a built-up block, *A*, and a thin veneer, *B*, with screws *C,C*, inserted through the block from the back, one near the straight part of the riser *D*, and one near the newel post *E*. Since, however, the curve of the bullnose riser *B* is only a quarter circle, it is possible to bend the actual riser of the usual thickness around the block as shown at *B* in Fig. 63.

In order to make it easier to bend the comparatively thick riser, it is customary to make a series of vertical saw cuts spaced close together along the back of the end of the riser. This removes a certain amount of material from the back of the riser and thus makes it more flexible. The process is called *kerfing* and is employed whenever it is necessary to bend a piece of wood too thick to be bent otherwise. The depth of the kerfs should be equal to about two thirds of the thickness of the wood to be bent.

Half-Space Stair with Rectangular Wellhole. Fig. 64 shows in plan, and Fig. 65 shows in section and partial elevation, a rather

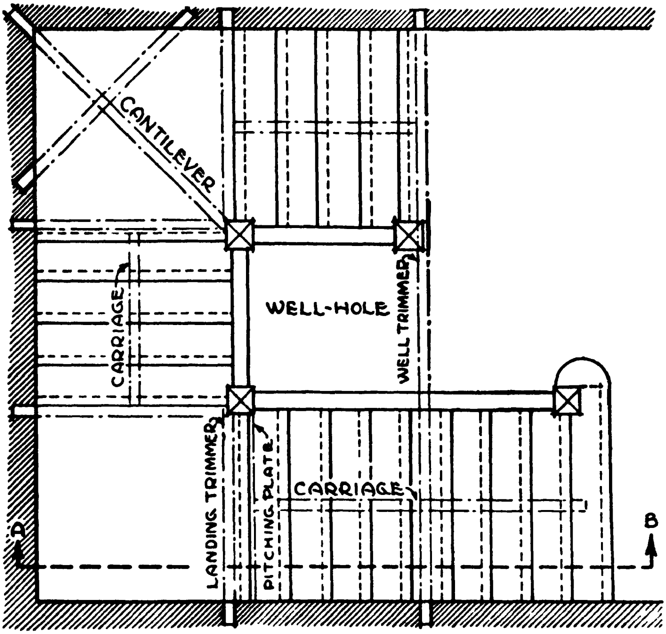


Fig. 64. Plan of Open-Newel Stair with Two Landings and Closed Strings

spacious *half-space* or *wide-U* stair built around a rectangular well-hole, with enclosing walls on three sides of the stair. Such a stair might be placed at the end of an entrance hall opposite the main entrance doors as in Fig. 66. In Fig. 64 the framing timbers which occur underneath the treads and landings, as well as the risers, are shown dotted. In this case it is assumed that the three enclosing walls, which may be of masonry or of wood studs, will receive and support the ends of the trimmers which in turn support the carriages.

The inside end of the trimmers at the first landing are carried on the second newel post which is carried down under the landing in the form of a post, *D*, Fig. 65. The inside end of the trimmers at the second landing are carried on the end of a cantilever beam brought out under the landing and supported from the two enclosing walls, as shown in Fig. 64, by means of a diagonal beam placed under the cantilever.

The newel post at the corner of the second landing is therefore

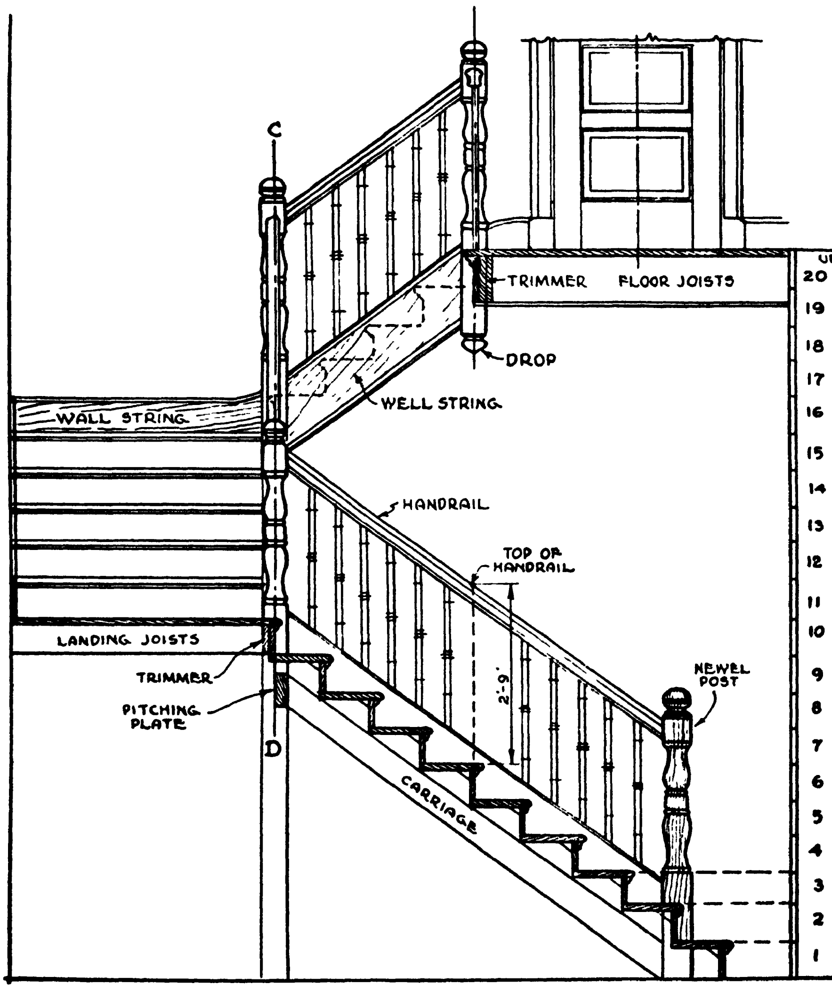


Fig. 65. Section of Stair, Plan of Which Is Shown in Fig. 64

not depended upon for support of the landing or the strings and will itself be supported by the trimmer joists. It will, therefore, not need to be extended down to the floor framing below and may be finished off at the bottom with a *drop* similar to the top newel which is shown in Fig. 65. The drop may be finished off with a turned or carved member, as shown, similar to a newel cap but reversed in that it hangs down below the underside of the string. The top newel is supported by the *well trimmer* which extends straight across the entire stair well space from wall to wall and is supported at each end on the wall, as shown in Fig. 64.

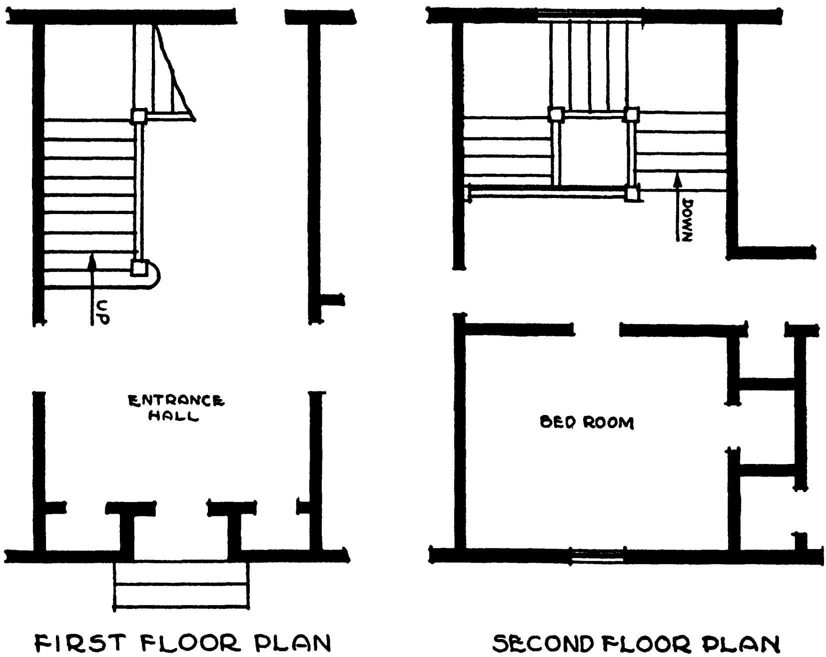


Fig. 66. Application of Open Newel Stair to a Building Plan

Winding Stair. For the type of stair shown in Fig. 64 the wellhole is rectangular, but more elaborate and expensive staircases are often built in which the wellhole is circular or elliptical. Fig. 67 shows a plan of a staircase of this kind, which is called a *winding* stair. Only about half of the steps in this stair, four at the top and four at the bottom, are ordinary steps or flyers. The remainder of the steps are all winders, but as the treads do not come to a point at the inside string as do the winders in Fig. 53, they are called *dancing* winders or *balanced* winders. They are much safer and more desirable than the ordinary type of winders. If the lines of the faces of the risers were to be extended past the inside string, they would meet on the center line of the stair well.

It is usual in winding stairs of this kind to try to make the width of the winders at a distance of 18 inches from the inside handrail the same as the width of the ordinary flyer treads in the same stair. This means that in Fig. 67 the distance between the lines *15* and *16*, for instance, at a point 18 inches from the inside handrail would be the same as the distance between the lines 4 and 5 or the lines *21* and *22*.

Framing. The framing for a winding stair such as is shown in

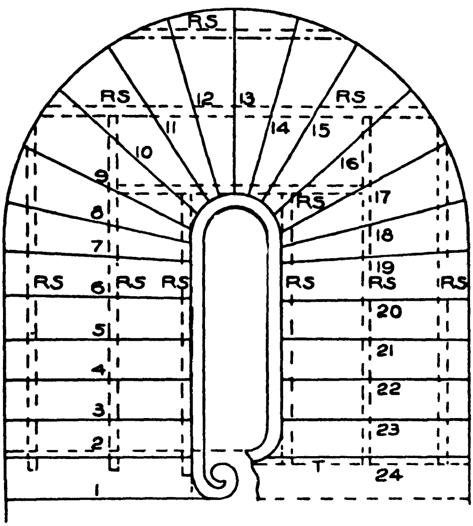


Fig. 67. Plan Showing One Method of Constructing Carriage and Trimming Winding Stair

Fig. 67 is of course much more difficult than the framing for an ordinary straight stair. The best way to start the framing is to lay the stair out carefully to scale, or better still, to full size, on the floor. In Fig. 67 the risers are numbered beginning with *1* at the bottom and continuing to *24* at the floor-level above. The supporting timbers, marked *R S*, which are all framed together so as to support the staircase, are indicated by dotted lines. Taken all together, these timbers are called *the carriage*. It is assumed that all around the outside of the staircase is a wall of masonry or of wood studding, as is almost always the case.

At the top of the stairs behind riser *24* is a *trimmer beam, T*, which spans clear across the stair well and is supported at each end in the walls. This trimmer beam is horizontal, or level, and carries the edge of the floor or landing at the head of the stairs.

About half way down the staircase at *RS, 12, 13, RS,* is another beam which spans clear across the stair well between walls, but this beam cannot be level since it must support the risers, and the point at which riser *16* crosses it is evidently at a higher level than the point at which riser *10* crosses it. This beam must therefore be inclined, but it is firmly supported at each end by the walls. The two beams

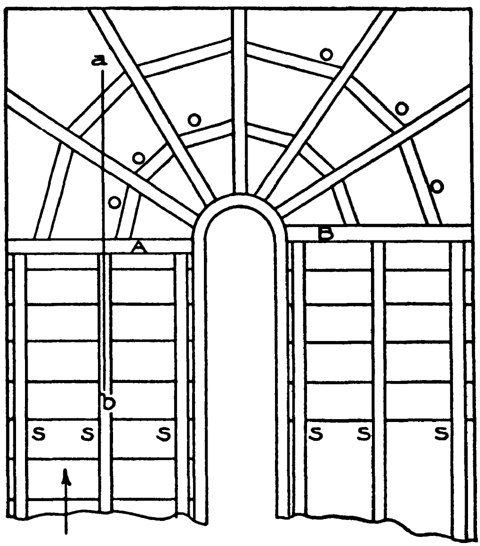


Fig. 68. Under Side of Stair with Carriages and Cross-Carriages

mentioned support the ends of all the other stringers or carriages as shown. These slope to conform to the slope of the under side of the stairs, and the top edges may be cut out to fit the horizontal treads and vertical risers of the stairs, somewhat as shown in Fig. 21, or they may be made like the carriage shown in Fig. 38 and the supporting blocks for the treads may be built up on top of them somewhat as shown in that figure.

Another method of constructing the carriage for a winding stair somewhat like the stair shown in Fig. 67 but enclosed in a rectangular stair well and with ordinary winders instead of dancing winders is shown in Fig. 68. In this figure *SSS* are the strings or carriages for the straight parts of the stair; those on the left-hand side of the stair well support the treads and risers of the flight from the first-floor level up to the winders, and those on the right-hand side of the stair well support the steps from the winders up to the second-floor level. One end of each of the carriages *SSS* is supported at the floor level, and the other end is framed into and carried by the member *A* on the left, and the member *B* on the right. These headers are both horizontal, but they are not both at the same level. The left-hand end of *A* and the

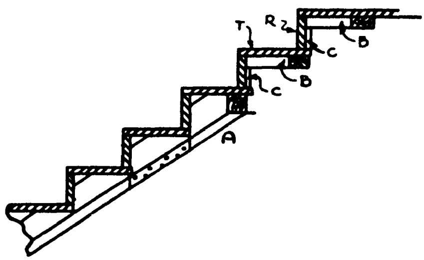


Fig. 69. Method of Reinforcing Stair

right-hand end of *B* are carried on the walls of the staircase enclosure, while the inner end of each of them is framed into and supported by the string which, as will be seen, is continuous from the first floor up to the second floor, curving around the stair well as it ascends. The curved portion of this *well string* also supports the inner ends of a series of timbers which radiate from it like the spokes of a wheel from the hub, and which are located one under each riser of the winders. These radial timbers are of course not all at the same level, but each one is about 7 inches (the height of a stair riser) above the one before it, beginning at *A* and ending at *B*. This places *B* about 4 feet higher up than *A*. The outer ends of all of the radial timbers are supported in the enclosing walls, and the inner ends on the curved well string; and each of these radial timbers, called *cross carriages,* is horizontal and level throughout its own length. They are not very long, only about 4 feet (the width of the stair) and need not be very large.

The pieces *O,O* are cut in between the cross carriages and these also are horizontal, though at different levels. They are located directly under the treads of the winders as shown at *B,B* in Fig. 69, which is a section taken on the line *ab* in Fig. 68. In Fig. 69, *A* is a section through the timber marked *A* in Fig. 68, and it will be seen how the tread *T* of the step immediately above the timber *A*, is made wide enough so that it projects under and beyond the riser *R*, above, thus forming a sort of shelf behind the back of the riser. This shelf supports a 1x3-inch upright member (*C* in Fig. 69) about 4 inches long which is wedged in under the end of the 2x3-inch piece *B* and supports the end of it. The other end of *B* is supported by the radial cross carriage in each case. In this way a solid support is provided for both the risers and the treads of the winders, depending,

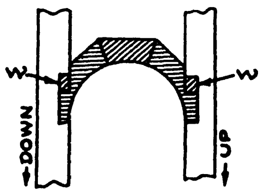


Fig. 70. One Method of Making a Well Cylinder

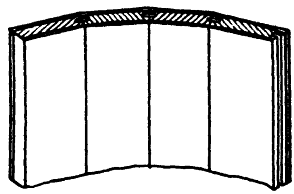


Fig. 71. Building Up a Curved Panel or Quick Sweep

however, entirely on the radial cross carriages which in turn are supported at one end on the curved part of the well string.

The well string is the weakest point of this construction, as everything depends upon the stability of the curved part of the well string, called the well cylinder since it is actually a section of a hollow cylinder about 18 inches in diameter and 4 feet high. Its top and bottom surfaces are steeply inclined to follow the rake of the well strings which must be securely attached to the well cylinder. The well cylinder may be built up out of straight pieces of stuff which are fairly thick and shaped and fitted together as shown in Fig. 70, where the cylinder is indicated cross-hatched and the two strings are plain. The cylinder is shown notched out on the back to fit into rabbets cut in the strings and space is left for two wedges *W* and *W*, which must be driven in tight. One string of course slopes down and the other string up with reference to the cylinder. Cylinders of somewhat greater diameter called "quick sweep" are sometimes built up and shaped from narrow thick plank with edges beveled and splined together as shown in Fig. 71. It is better, if possible, to support the cylinder from the floor below, but sometimes it is desired that the entire soffit or underside of the staircase should be exposed and finished with plaster.

After the well or cylinder has been put together in the rough as shown in Fig. 70, it can be finished up, the rough corners can be smoothed off and it can be thus made to conform to the cylindrical shape shown in plan in Fig. 68 between *A* and *B*.

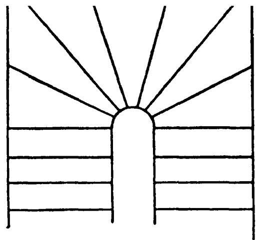


Fig. 72. Geometrical Stair with Seven Winders

Fig. 72 shows a plan view of a stair similar to that shown in Fig. 68 but with 7 winders instead of 6, and it will be seen that the treads and risers of the winders have their *inner* ends all clustered around the cylinder at the wellhole, and that the 7 treads are all of equal width at this inside end, but are very narrow (perhaps about 3 inches wide) while the risers, even at this point where they meet the cylindrical part of the inside string, are necessarily of the same height as they are at any other part of the stair, that is, about 7½ inches high. This means that the stair is very steep at the wellhole. Fig. 73(A) shows a plan view of a circular stair in a circular enclosure with 9 winders grouped around the cylindrical wellhole, all with treads of equal width, but even narrower, where they intersect the well cylinder, than treads of the 7-winder stair. Risers are of normal height around this cylinder.

Well Cylinder. Imagine that the curved surface of the cylindrical well string which receives these treads and risers is flattened out or *unwound* from its cylinder just as one would unwind the cover of a rolled up magazine and flatten it out: the distance *around* the half-cylinder spread out in a straight line would be equal in length to the sum of the widths at the cylinder of all the 9 stair treads which intersect the cylinder. Fig. 73(B) shows this *developed* surface of the well-string cylinder and shows how the lines of the treads and risers will appear where they intersect this cylindrical well-string surface.

Since the widths of the treads are all equal and the heights of the risers are all equal, a line drawn through the nosings of all the 9 steps will be a *straight* line in the unwound or developed surface of the well-string cylinder just as it would be in the case of the string for a straight-run staircase.

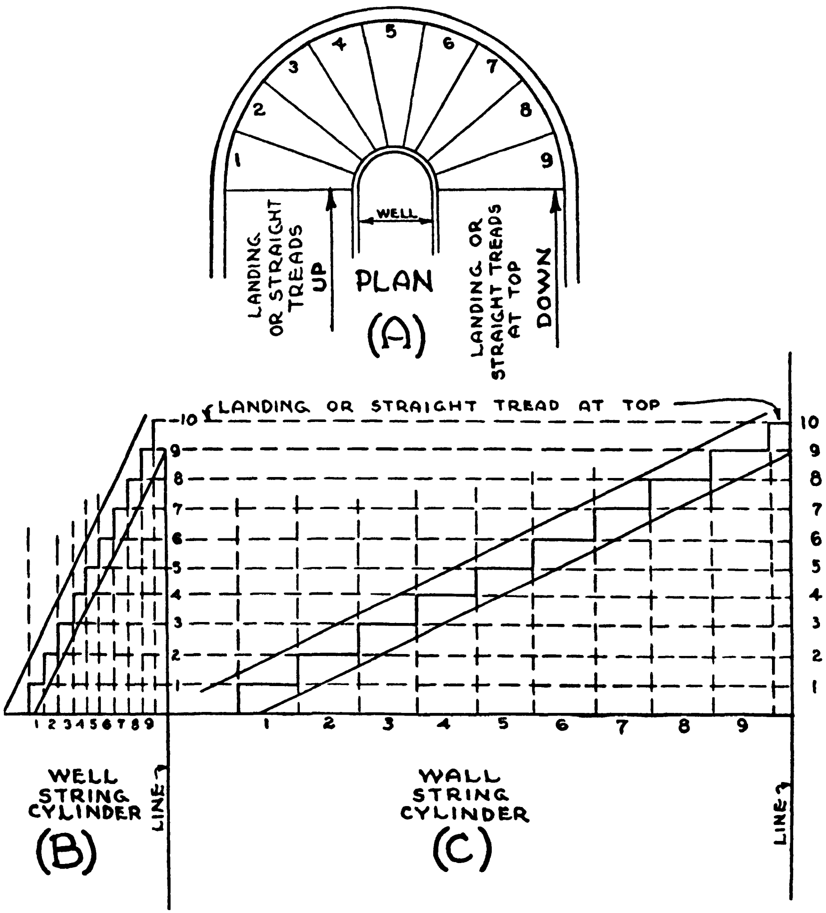


Fig. 73. At (**A**), Plan of Stair with 9 Winders on a Cylindrical Well Hole; (**B**) Developed Surface of Well-String Cylinder; (**C**) Developed Surface of Wall-String Cylinder

In order to mark off the lines of the treads and risers on the finished surface of the well-string cylinder, a full-sized pattern similar to Fig. 73 (B) could be made on stiff paper, and could be bent around the curve of the cylinder and thus used for marking off the lines of the treads and risers.

Outside String or Wreath-Piece. Fig. 73(*A*) shows *1, 2, 3, 4* etc., the intersection in plan of the 9 treads with the cylindrical *outside* string. The treads here are three or four times as wide as the treads in Fig. 73(B) but the height of the risers is the same. This means that the *outside* string, in going around the curve formed by the semicircular *enclosure* of the staircase, does not slope up as steeply as does the inside string. It rises exactly the same distance (the height of nine risers) as does the inside string, but in doing so it passes through a horizontal distance around the curve, a distance from seven to nine times as great as the horizontal distance traversed by the inside string in rising the same height. Fig. 73(C) shows how the outside string may be laid out, and shows also that this string

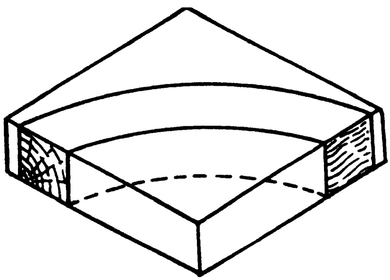


Fig. 74. Curved Segment of a Circle Cut from Thick Plank

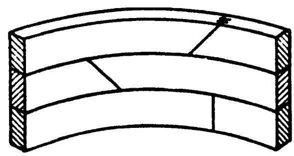


Fig. 75. Wreath-Piece Built of Curved Segments

in its unwound or developed form has a regular and continuous slope, due to the fact that the widths of all treads are equal and the heights of all risers are equal.

If it were possible easily to bend a board of ordinary thickness around the curve formed by the enclosing walls of the circular stairway, the outside string could be actually laid out on a straight piece of stuff using a pitch-board such as that shown in Fig. 23, and the finished string could then be bent into its place.

Another way would be to lay out the lines of the treads and risers on a piece of dressed lumber to full size on the floor, somewhat as shown in Fig. 73(C), and then to bend the finished string into its place against the curved enclosing wall where it would be found that the housing for the treads and risers would be in the correct positions to receive the outside edges of the treads and risers of the winders. This might be accomplished successfully by sawing kerfs* (grooves) in the face of the string parallel to the riser lines to make the piece of lumber bend more easily, but, since the kerfs must be cut on the face of the stuff, it is almost impossible to cut them so that they will be inconspicuous in the finished work.

Another way would be to cut curved segments of a circle from thick plank, as shown in Fig. 74. By means of glue and screws these are fastened together edge to edge and end to end as shown in Fig. 75 until the resulting curved casing is big enough to allow the curved portion of the string to be cut out from it. This is called *staving* the string. The curved blocks sometimes have the heading joints tongued and grooved.

The curved part of the string in any staircase, as well as the

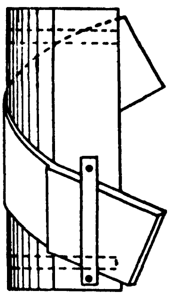


Fig. 76. Wreath-Piece Bent around Cylinder

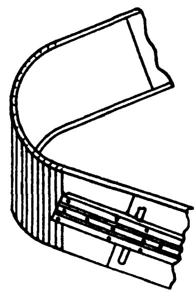


Fig. 77. Completed Wreath-Piece Removed from Cylinder

curved portion of the handrail, is called a *wreath-piece* or simply a *wreath.*

Another method of forming such a wreath-piece for the outside string of a circular stair is to take a short piece of stuff of suitable width and thickness for the string and cut away the back until it becomes very thin, almost like a veneer as shown in Fig. 76. By one of the methods described, build up a rough cylindrical form having a radius equal to the radius of the stairway at the turn or half space; large enough, for example, to correspond to a portion of the curve *1, 2, 3, 4, 5, 6, 7, 8, 9* in Fig. 73(A). Such a cylindrical form is shown in Fig. 76 by the vertical lines. Bend the thin veneer-like piece of the string around the cylindrical form, keeping it always at the proper slope with reference to a horizontal or level line; then clamp it tight around the cylindrical form by means of hand screws. While it is held in this position, fill out the thinned portion of the veneer by gluing into place against the back of the veneer a series of narrow staves set close together in a vertical position with edges beveled to fit closely together. When the glue has dried, the curved piece of string may be removed from the form as shown in Fig. 77 which by the vertical lines also shows the staves glued to the back to fill out the thinnest part. The result is a short piece of string bent to the required curve. Then another short section of the curved string can be formed in the same way and spliced to the first section, and so on, until the entire wreath-piece has been formed, after which the outlines of the steps as shown in Fig. 73 (C) can be marked out on it. The splice may be made by gluing staves across the joint.

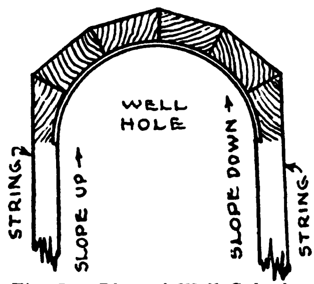


Fig. 78 Plan of Well Cylinder Formed from Curved Veneer Stiffened with Staves on Back

In Fig. 78 is shown a plan view of a well string curved around a semicircular wellhole and formed by the method just described. The curved wreath-piece next to the wellhole has been cut very thin. After being curved, it has been filled out to the required thickness by having wedge-shaped staves glued to the back of the curved portion.

Another method of building up a curved string is to start with a piece of stuff so thin that it can be bent around the cylindrical form, and lay out a portion of the string on this veneer board; then bend it around the cylinder. The required thickness (about $1\frac{1}{4}$ inches) is obtained by gluing similar thin veneer pieces against the first piece. Each veneer is held in place long enough for the glue to dry. Places are left at the ends for splicing. When the required thickness of the string has been built up, the finished short piece of string is removed from the cylindrical form. Another section of the string is then started in the same way and spliced to the first section by breaking joints in the veneers while being built up to the proper thickness.

Thus a curved string of any thickness and of almost any length can be formed a few feet at a time. Fig. 77 shows also how the curved wreath-piece is secured to the ends of the straight parts of the string by means of pieces screwed onto the back and by means of a cross-piece called a counter-wedge key.

Framing by Use of Sloping Stringers. Fig. 79 shows another

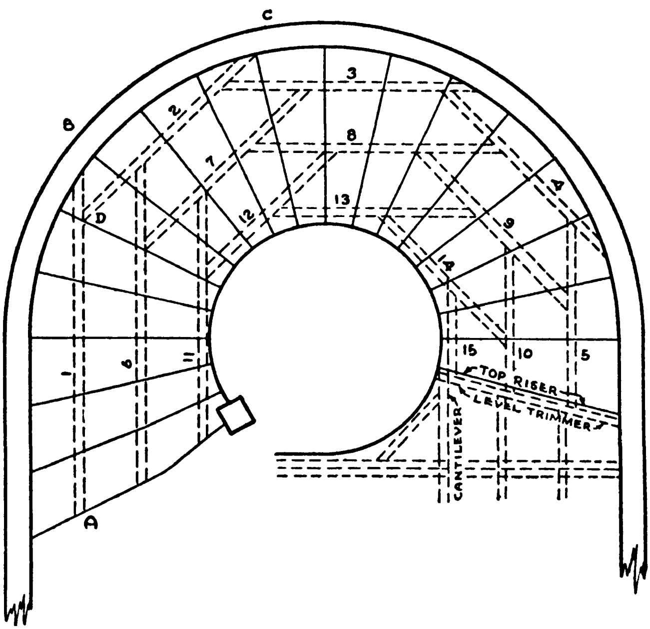


Fig. 79. Framing for Carriage of a Circular Stair

method of framing the carriage for a circular stair. The enclosing walls of the stair well are assumed to be circular in plan, composed either of masonry or of wood studding, but in either case capable of supporting one end of the stringers. The stringers or carriages are arranged so as to follow as closely as possible the slope of the underside of the staircase. On account of the circular curve of the staircase in plan, it is impossible for the ends of the stringers to rest in all cases on either the floor framing or the enclosing walls, so they must be made to support each other as shown. Stringer *1* is placed first, with its lower end resting on the floor at *A*, and its upper end resting on the curved enclosing wall at *B*. Stringer *2* is placed next, with its upper end supported in the wall at *C* and its lower end resting against stringer *1* at *D*. Stringers *3* and *4* are placed one after the other, each with its upper end in the wall and its lower end supported

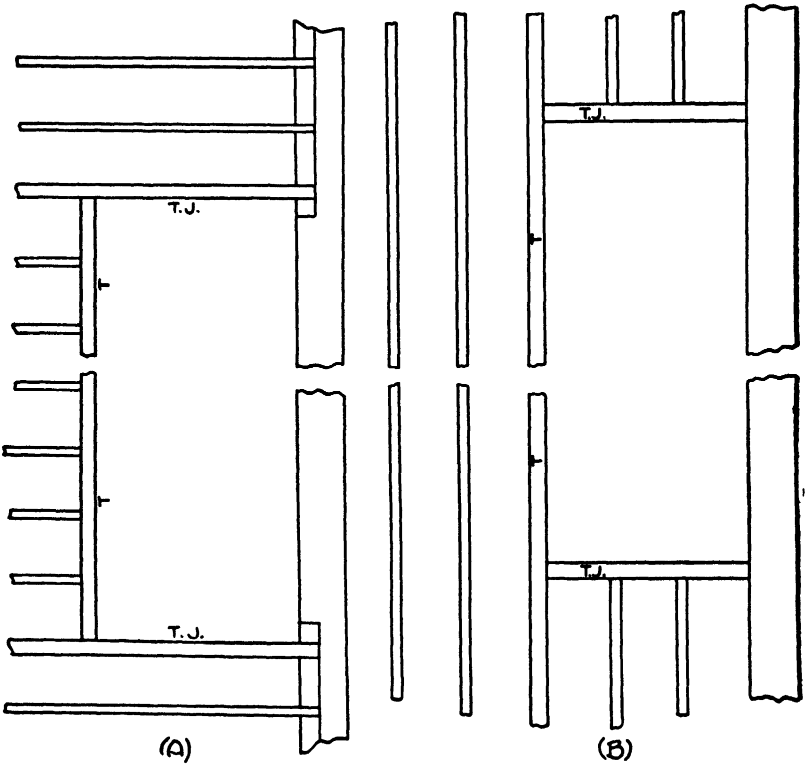


Fig. 80. Ways of Trimming Wellhole (A) When Joists Run Perpendicular to Length of Stair Well; (B) When Joists Run Parallel to Length of Stair Well

by the preceding stringer. Stringer *5* is supported at its upper end by the framing of the floor above, and its lower end by *4*. This completes the outside line of stringers.

The middle line of stringers is then placed, beginning with *6*, the lower end of which is on the floor, while its upper end is carried by stringer *2*. Stringer *7* has its lower end on *6* and its upper end on *3*. Stringer *8* has its lower end on *7* and its upper end on *4*. Stringer *9* is supported by stringers *8* and *5*, while *10* has its upper end on the second floor framing and its lower end on *9*.

The inside line of stringers is next erected in a similar manner, beginning with *11*, with lower end on floor, and upper end on *7*; then *12* with lower end on *11*, upper end on *8*; followed by *13*, supported by *12* and *9*; and *14* carried by *13* and *10*. Stringer *15* has its upper end at the second floor framing and its lower end resting on *14*. In this way all the sloping stringers are erected, each one with both ends properly supported, although only a few of them rest on either the floor framing or the enclosing walls.

Wherever stairs occur, it is necessary to prepare an opening through the floor to make it possible to pass comfortably up and down. Such an opening is called a wellhole. When the joists and beams for the floor framing are being laid out and cut, provision must be made for the wellhole or the stair well, as this requires special framing.

Trimming the Wellhole. Fig. 80 shows two methods of *trimming*, as it is called, around a wellhole, depending upon the relation of the length of the wellhole to the direction of the floor joists. One long side of the wellhole is shown placed against a wall, a condition which often occurs but not always. When there is no wall, the framing on the two sides of the wellhole would be the same.

The arrangement of the trimming varies according to whether the floor joists run parallel or at right angles to the longer side of the wellhole. With the joists at right angles to the long side of the stair well, shown in Fig. 80 at *A*, heavy *trimmer joists TJ* and *TJ* are placed at each end of the wellhole running parallel with the floor joists, and a heavy trimmer *TT* is framed in between them at the side of the stair well as shown. This trimmer beam would in most cases be supported from the trimmer joists *TJ* by means of steel beam hangers.

Where the joists are parallel to the long side of the stair well as in Fig. 80 at *B*, the timber at the side of the wellhole is made somewhat heavier than the ordinary floor joists, and into it are framed short trimmers, *TJ*, at the two short ends of the stair well as shown.

Factory Stair. Factory stairs are somewhat similar to the cellar stairs illustrated in Fig. 20, but are of heavier construction to withstand the greater amount of wear to which they are sure to be subjected. Such stairs are usually built with no risers and with heavy strings, perhaps 2 x 12 or 3 x 12 inches, cut out to receive the treads which may be of plank two inches thick. Ordinarily, factory stairs are built in an enclosure separated from the factory space by a fireproof wall or partition (which may be built of any fireproof material

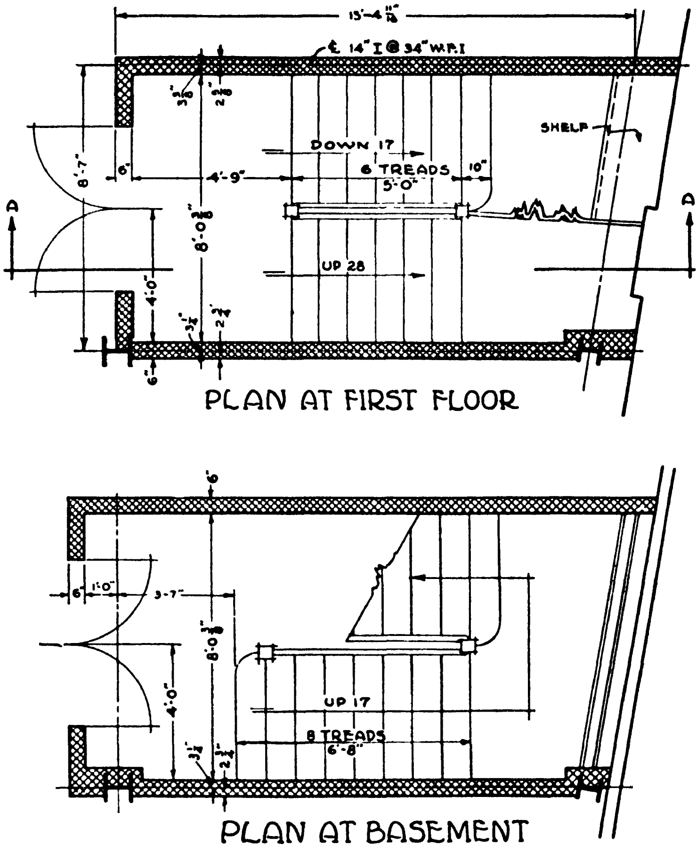
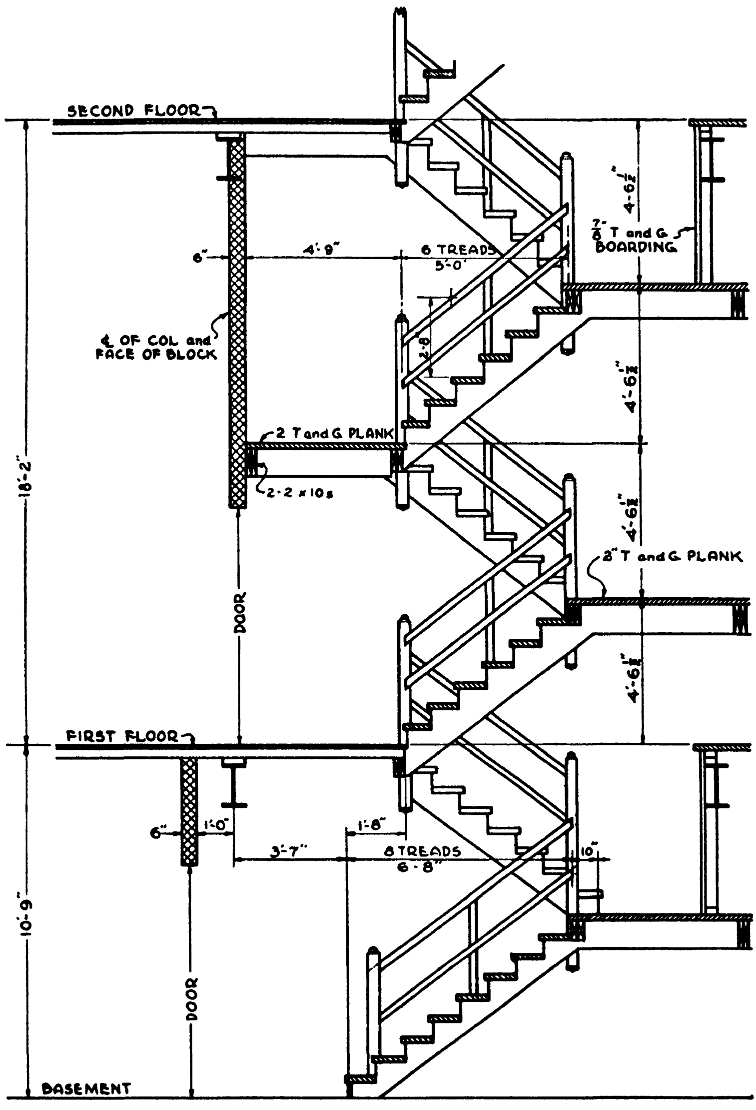


Fig. 81. Plan of Factory Stairs

such as concrete blocks, terra cotta block, or solid brick) and at each floor level there is a fireproof door leading from the stair enclosure to the factory space. Figs. 81 and 82 show, to scale, plans and a sectional view of a staircase in a factory where there are several floors.

As the floor-to-floor height in a factory is usually fairly high, there will be at least one and sometimes two intermediate landings between floors, as shown in Fig. 82. The handrails and newel posts will be very simple in design, but strong and sturdy to withstand hard wear. Fig. 83 shows a detail of the newel post and the railing, as well as of the treads and string. This figure will have to be compared with Fig. 82 which shows, to smaller scale, a sectional elevation of the staircase.



SECTION A-A

Fig. 82. Elevation of Factory Stairs

The factory containing the stair has a steel frame with heavy plank floors and the steel columns and beams are shown in Figs. 81 and 82. The stair well is framed partly with the steel beams and partly with heavy wood beams. The stair landings are constructed of wood beams and 2-inch plank.

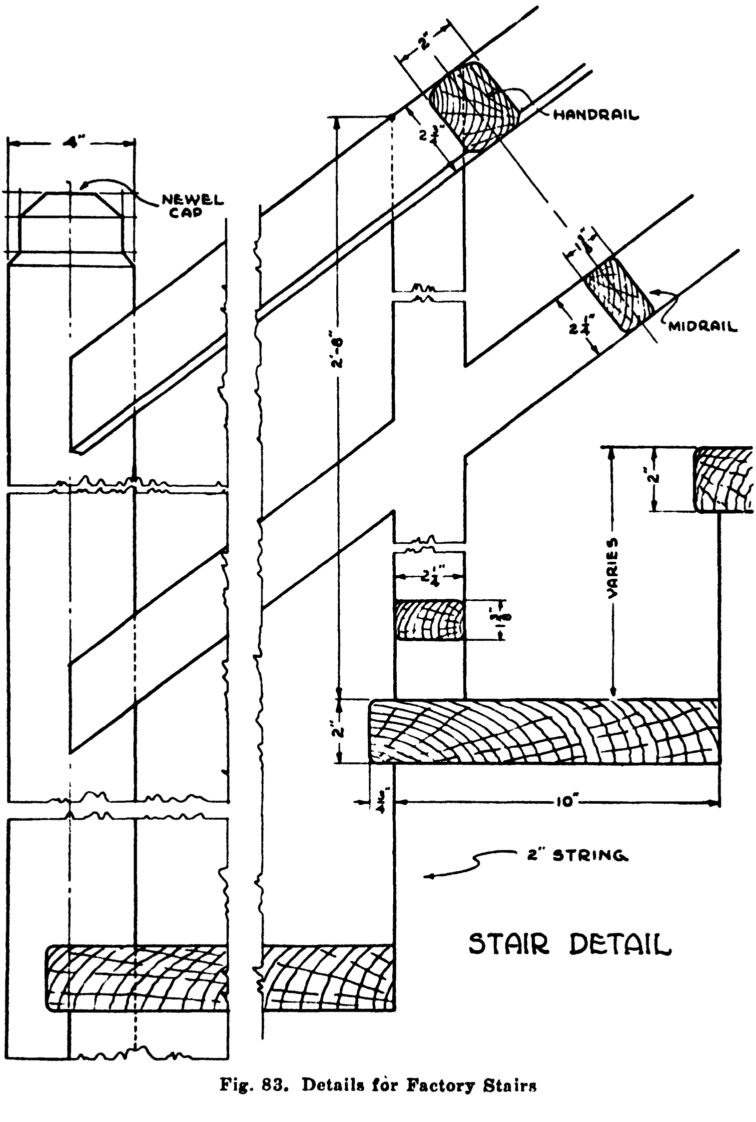


Fig. 83. Details for Factory Stairs

CHAPTER III

LAYING OUT OR DESIGNING STAIRS

Experience extending over hundreds of years in the designing and use of stairs has resulted in the establishment of certain rules governing the width and length of staircases of different types, the smallest allowable headroom at critical points, and the proportion of the height of risers to the width of treads. In most cases these rules are known to and followed by designers and builders of stairs and if through ignorance or necessity they are not adhered to, the result is sure to be a stairway too steep or too narrow for comfortable use or for the necessary passage of furniture.

Treads and Risers. As regards the treads and risers, it goes without saying that the width of a tread must be greater than the height of a riser. Three rules frequently mentioned and used for inside stairs are as follows:

1. The product obtained by multiplying the height of the riser (from tread to tread) in inches, by the width of the tread (from face to face of risers) in inches, should be between 70 and 75. Thus either a 10-inch tread and a 7-inch riser, or a 9-inch tread and an 8-inch riser would be acceptable. A better rule is to make this product equal to at least 75, which would eliminate the 9-inch tread with 8-inch riser, as these dimensions do not result in a good stair, though in some cases acceptable for attic or cellar stairs.

2. The sum obtained by adding the width and height in inches of one tread and one riser should be 17 to 18. Thus a 10-inch tread and a riser from 7 to 8 inches high, or an 11-inch tread and a riser from 6 to 7 inches high would be acceptable according to this rule. Rule 1 should, however, be used as a check on this rule and if this were done the 10-inch tread with 8-inch riser would be ruled out because the product is too much, being 80, while the 11-inch tread and 6-inch riser would be ruled out because the product is too little, being only 66. However, this latter proportion would be suitable for outside steps to a public building such as a church.

3. The sum of 2 risers and 1 tread should be between 24 and 25.

Thus a 7 to 7½-inch riser with 10-inch to 11-inch tread would be acceptable.

For main staircases in houses, it has been found that risers should not be higher than 7⅝ inches nor less than 6⅝ inches (with 7 inches as most desirable) combined with a tread width (face to face of risers and not including nosing) of 10½ to 11 inches. Risers

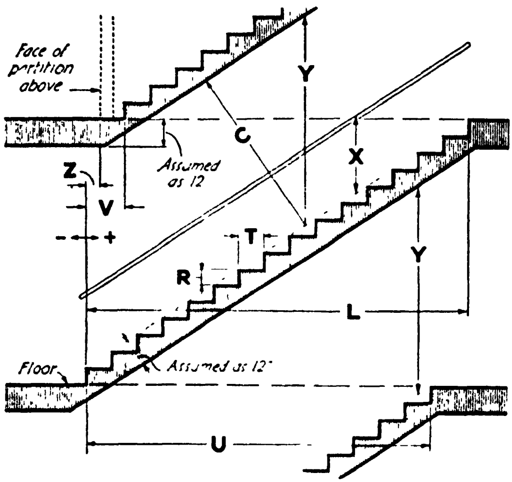


Fig. 84. Dimensions for Straight Run Stairs as Given in Stair Table (Fig. 85)

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for attic and cellar stairs may, if necessary, be as high as 9 inches, although this extreme height is very undesirable and should be used only when it is unavoidable.

The height from floor to floor is usually fixed by considerations independent of the stairs. It is, then, evident that the higher each riser of the stair is, the fewer risers and treads there will be; and the fewer treads there are, the less space the stairs will occupy. This is why attic and cellar stairs frequently have high risers and narrow treads.

Knowing the height from floor to floor in inches, this height is divided by 7 inches, which perhaps gives a whole number and a fraction. For instance, if the height, floor to floor, is 9 feet (which equals 108 inches) this, divided by 7 inches, is 15³⁄₇. This gives an idea of the number of risers to use so as to have a riser height of about 7 inches.

In the case quoted, say that there will be 15 risers. Then, di-

Stair Table

Dimensions in Feet and Inches—See Fig. 84.

Floor-to-Floor Height	No. of Risers	Riser R	Tread T	Total Run L	Min. Head-room Y	Handrail X	Clearance C	Partition Above Z*	First Riser Below - U	First Riser Above-V*
8′-0″ †	11	8.73″	8¼″	6′-10½″	8′- 2″	2′-10″	5′- 8″	-1′-10″	8′- 6″	-1′- 7″
†	12	8.00	9	8 - 3	7 -10	2 - 9½	5 -10½	-1 - 8½	9 - 7½	-1 - 4
	13	**7.38**	**10¼**	**10 - 3**	**7 - 7**	**2 - 9**	**6 - 2**	**-1 - 8½**	**11 - 6**	**-1 - 1½**
	14	**6.86**	**11½**	**12 - 5½**	**7 - 4**	**2 - 9**	**6 - 4**	**-1 - 7**	**13 - 5½**	**- 9½**
‡	15	6.40	12½	14 - 7	7 - 3	2 - 9	6 - 7½	-1 - 6½	15 - 5½	- 7½
‡	16	6.00	13½	16 -10½	7 - 3	2 - 9	6 - 7½	-1 - 9	17 - 6	- 8
8′-6″ †	12	8.50	8½	7 - 9½	8 - 1	2 - 9½	5 - 8½	-1 - 3½	8 -10	-11
†	13	7.85	9¼	9 - 3	7 - 9	2 - 9½	5 -10½	-1 - 1	9 -10	- 7½
	14	**7.29**	**10½**	**11 - 4½**	**7 - 6**	**2 - 9**	**6 - 2**	**-10½**	**12 - 9**	**- 4**
	15	**6.80**	**11½**	**13 - 8½**	**7 - 4**	**2 - 9**	**6 - 4**	**-10½**	**13 -10**	**- 1½**
‡	16	6.38	12½	15 - 7½	7 - 3	2 - 9	6 - 5½	- 7	15 - 5½	+ 3½
‡	17	6.00	13½	18 - 0	7 - 3	2 - 9	6 - 7	- 7	17 - 8	+ 5
9′-0″ †	12	9.00	8	7 - 4	8 - 3	2 -10	5 - 6	-11	8 - 1	- 8
†	13	8.31	8½	8 - 6	8 - 0	2 - 9½	5 - 9	- 9	8 -11½	- 5
	14	**7.71**	**9½**	**10 - 3½**	**7 - 9**	**2 - 9½**	**6 - 0**	**- 6**	**10 - 5**	**- ½**
	15	**7.20**	**10½**	**12 - 3**	**7 - 6**	**2 - 9**	**6 - 2½**	**- 3**	**11 -10**	**+ 4½**
	16	**6.75**	**11¾**	**14 - 8¼**	**7 - 4**	**2 - 9**	**6 - 4**	**+ 2**	**13 -11**	**+1- 0**
‡	17	6.35	12½	16 - 8	7 - 3	2 - 9	6 - 5½	+ 5	15 - 5½	+1- 4
‡	18	6.00	13½	19 - 1½	7 - 3	2 - 9	6 - 7½	+ 6	17 - 8	+1- 6
9′-6″ †	13	8.77	8	8 - 0	8 - 2	2 -10	5 - 5½	- 3½	8 - 2	- ½
†	14	8.14	9	9 - 9	7 -10	2 - 9½	5 - 9½	± 0	9 - 5½	+ 5
	15	**7.60**	**9¾**	**11 - 4½**	**7 - 7**	**2 - 9**	**5 -11½**	**+ 4½**	**10 - 7**	**+10½**
	16	**7.13**	**10¾**	**13 - 5¼**	**7 - 5**	**2 - 9**	**6 - 2**	**+ 9½**	**12 - 2**	**+1- 5½**
	17	**6.71**	**11¾**	**15 - 8**	**7 - 4**	**2 - 9**	**6 - 4**	**+1- 1½**	**13 -11½**	**+1-11**
‡	18	6.33	12½	17 - 8½	7 - 3	2 - 9	6 - 5½	+1- 5½	15 - 7	+2- 4
‡	19	6.00	13½	20 - 3	7 - 3	2 - 9	6 - 8	+1- 8	17 - 9	+2- 7½

Notes: Figures in bold face indicate stairs recommended for most interiors
*Dimensions given plus or minus; i e behind or in front of first riser (see Fig. 84).
†Indicates stairs allowable only for attics and cellars but not recommended.
‡Indicates stairs for exterior or monumental use.

Fig. 85. Table for Straight Run Stairs

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viding the floor-to-floor height of 108 inches by 15 gives the riser height of $7\frac{3}{15}$ inches or $7\frac{3}{16}$ inches, nearly.

Knowing the height of the risers, the width of the treads from face to face of risers can be selected by applying one or all of the three rules quoted above. If there are 15 risers, there will be 14 treads, because the number of treads is always just one less than the number of risers. The width of tread selected (say 10 inches) multiplied by the number of treads (14 in this case) gives the run of the

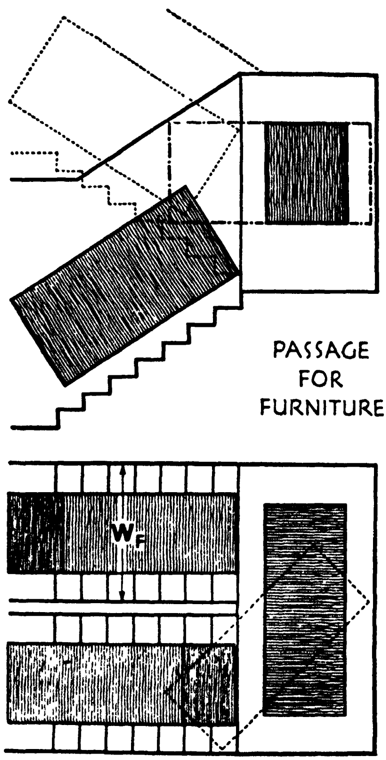

Fig. 86. Diagrams Showing Clearance Necessary for Furniture Movement on Stairs

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stair from the face of the first riser at the bottom to the face of the last riser at the top. In the case being considered, this run will be 14 x 10 inches, which equals 140 inches, or 11 feet and 8 inches. If this run is too great for the space available, the width of each tread might be reduced a little, but not much, without violating one of the three rules quoted above. If the run is still too much, try reducing the number of risers to 14 and the number of treads to 13. The height of each riser will then be 108 inches divided by 14, which is $7\frac{5}{7}$ inches (still within allowable limits) calling for a width of tread

Recommended Minimum Clear Widths of Stairs (WF)*
For Furniture Movement—See Fig. 86.

Furniture		Min. Headroom†		Unlimited Headroom		
		Wide U Type	Narrow U Type	Wide and Narrow U	Narrow U Only**	
Article	Size				Stair	Landing
Double bed box spring..	4′- 6″x6′- 6″x0′- 8″	3′- 2″	3′- 2″	2′- 3″		
Dressing table........	1 -10 x4 - 0 x2 - 6	2 - 5	2 - 5	2 - 5		
Bureau..............	2 - 0 x4 - 0 x3	2 - 8	2 - 8	2 - 8		
Chiffonier	1 - 8 x3 - 4 x4 - 8	2 - 6	2 - 6	2 - 6		
Chest of drawers......	1 - 9 x3 - 4 x4 - 8	2 - 7	2 - 7	2 - 7		
Divan—club	3 - 6 x7 - 2 x2 - 9	4 - 8	4 - 8	3 - 4	3′-0″	3′-8″
Divan—average	3 - 0 x6 - 8 x2 - 6	4 - 4	4 - 4	2 -11		
Piano—concert grand..	9 - 0 x5 - 4 x1 - 8	4 - 8	4 - 8	3 - 2‡	3 -0 ‡	3 -4 ‡
Piano—music rm. grand	7 - 3 x5 - 2 x1 - 6	3 -10	3 -10	3 -10		
Piano—drawing rm. grand	6 - 9 x5 - 0 x1 - 4	3 - 6	3 - 6	2 -10		
Piano—baby grand....	5 - 8 x4 -10 x1 - 2	3 - 0	3 - 0	2 - 8		
Piano—standard upright	2 - 2 x5 -10 x4 - 6	4 - 0	3 - 9	3 - 3	3 -0	3 -6
Highboy—large . ..	2 - 0 x3 - 6 x7 - 6	4 - 4	4 - 4	2 -10		
Highboy—average....	1 - 8 x3 - 4 x6 - 0	3 - 6	3 - 6	2 - 6		
Secretary—large....	1 -10 x3 - 8 x7 - 2	4 - 0	4 - 0	2 -10		
Secretary—average...	1 -10 x3 - 0 x6 -10	3 -10	3 -10	2 - 6		
Sideboard	1 - 9 x5 - 0 x3 - 2	2 - 6	2 - 6	2 - 6		
Buffet...	2 - 1 x3 - 3 x6 - 5	4 - 0	4 - 0	2 -10		
Dresser	1 - 9 x6 - 0 x5 - 6	4 - 4	3 - 6	3 - 4	3 -0	3 -8
Table (6 people).. ...	3 - 6 x5 - 0 x2 - 6	3 - 2	3 - 2	3 - 2	3 -0	3 -4
Table (8 people)	3 - 6 x7 - 0 x2 - 6	4 - 8	4 - 4	3 - 2	3 -0	3 -4
Table (10 people) rnd..	6 - 4 diam.	4 - 8	4 - 8	3 - 0		
Desk—slope top	2 - 6 x3 - 8 x3 - 4	3 - 3	3 - 2	3 - 2	3 -0	3 -4
Desk—flat top	3 - 0 x5 - 6 x2 - 6	3 - 2	3 - 0	3 - 0		
Desk—executive's	3 - 2 x6 - 0 x2 - 6	4 - 2	4 - 2	3 - 1	3 -0	3 -2
Trunk—wardrobe ..	1 -11 x2 - 6 x3 - 7	2 - 5	2 - 5	2 - 5		

Notes: *Clear width between faces of rails, newels, etc. or between rail or newel and finish wall.
†Headroom limited to minimum comfortable human passage (See Stair Table).
**Narrow stairs and wide landings
‡Absolute minimum; not recommended

Fig. 87. Average Sizes of Articles of Furniture and Required Dimensions of Stairs to Allow Furniture Movement

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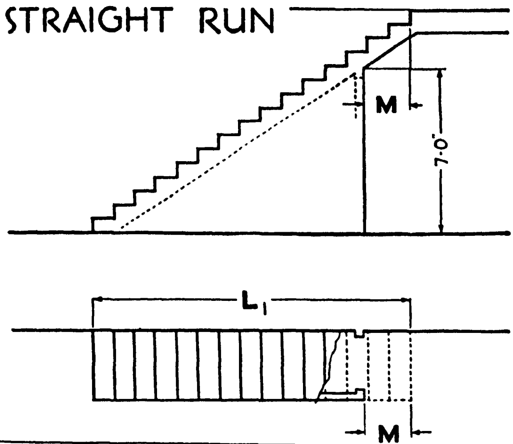
of 10 inches. The run of the stair is thus reduced to 13 x 10 inches, which is 130 inches or 10 feet and 10 inches.

Headroom. If two or more flights of stairs are arranged one



Height Floor to Floor	No. of Risers	Riser	Tread	L_1	M
8'-0"	13	7.38	10¼"	10'-3"	....
8'-6"	14	7.29	10½"	11'-4½"	4½"
9'-0"	15	7.20	10½"	12'-3"	1'- 1½"
9'-6"	16	7.13	10¾"	13'-5¼"	1'-11¼"

Fig. 88A. Dimensions for Straight Run Stair
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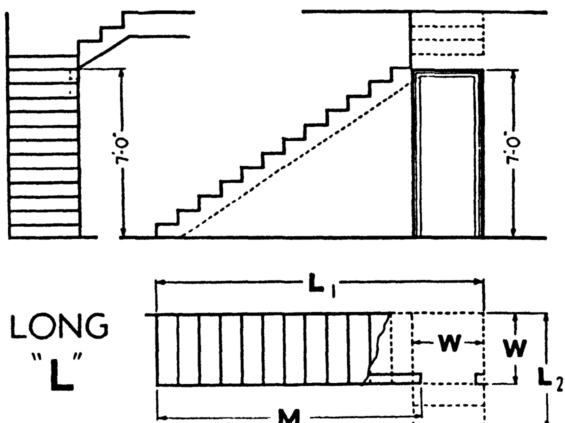

Height Floor to Floor	No. Risers	Riser	Tread	No. Risers	L_1	No. Risers	L_2	M
8'-0"	13	7.38	10¼"	13	10'-3"+W	0	W	10'-3"
8'-6"	14	7.29	10½"	13	10'-6"+W	1	W	10'-6"
9'-0"	15	7.20	10½"	13	10'-6"+W	2	10½"+W	10'-6"
9'-6"	16	7.13	10¾"	13	10'-9"+W	3	1'-9½"+W	11'-0"

Fig. 88B. Dimensions for Long L Stair
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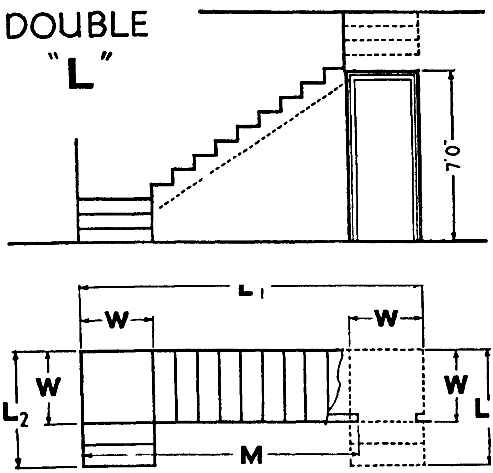
above the other in the same stair well (for example, cellar stairs under, or attic stairs over, the main staircase), the question of adequate headroom underneath the upper stair is introduced into the planning problem and must be considered most carefully. It has been found from studies of the dimensions of the average man or



Height Floor to Floor	No. Risers	Riser	Tread	No. Risers	L_1	No. Risers	L_2	M
8'-0"	13	7.38	10¼"	13	10'-3" +2W	0	W	10'-3" +W
8'-6"	14	7.29	10½"	12	9'-7½"+2W	1	W	9'-7½"+W
9'-0"	15	7.20	10½"	11	8'-9" +2W	2	10½"+W	8'-9" +W
9'-6"	16	7.13	10¾"	10	8'-0¾"+2W	3	1'-9½"+W	8'-3¾"+W

Fig. 89A. Dimensions for Double L Stair
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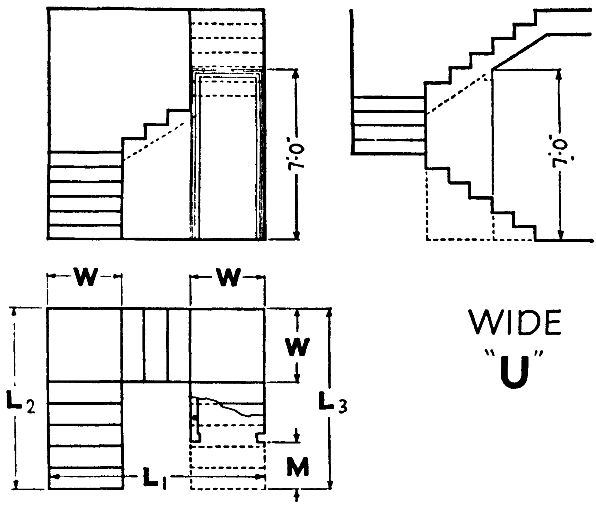
woman that this headroom, measured vertically from top of tread at face of riser up to the under side of the stair above, varies with the steepness of the stair, but is generally from 7 feet 4 inches to 7 feet 7 inches. This allows for the arm to be swung up over the head without hitting anything. This clearance should be increased slightly for steeper stairs.

The diagram shown in Fig. 84 gives a whole series of dimensions for straight run stairs indicated by letters, and reference to the Stair Table shown in Fig. 85 will give at a glance these dimensions in feet and inches for stairs with different floor-to-floor heights and having different numbers of risers for each floor-to-floor height. This information was compiled by Mr. Raymond Baxter Eaton and published in the *American Architect.*



Height Floor to Floor	No. Risers	Riser	Tread	No. Risers	L_1	No. Risers	L_2	No. Risers	L_3	M
8'-0"	13	7.38	10¼"	4	2'-6¾"+2W	4	2'-6¾"+W	5	3'-5" +W	....
8'-6"	14	7.29	10½"	4	2'-7½"+2W	5	3'-6" +W	5	3'-6" +W	4½"
9'-0"	15	7.20	10½"	4	2'-7½"+2W	5	3'-6" +W	6	4'-4½"+W	1'- 1½"
9'-6"	16	7.13	10¾"	4	2'-8¼"+2W	6	4'-5¾"+W	6	4'-5¾"+W	1'-11¼"

Fig. 89B. Dimensions for Wide U Stair

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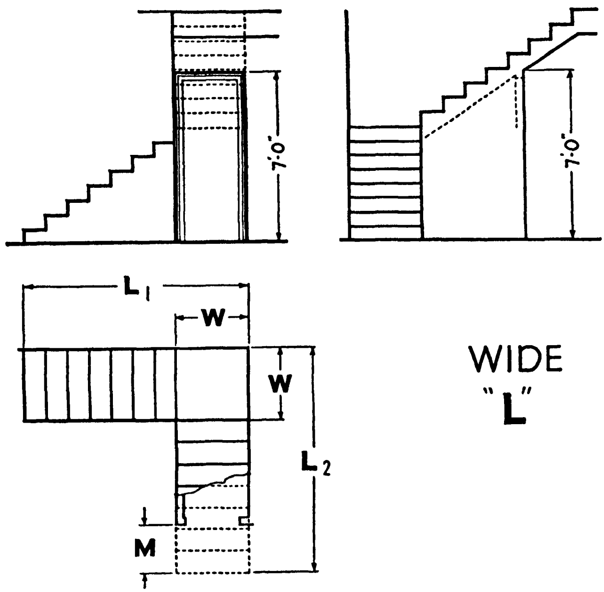
Stair Widths. The width of staircases is determined by the necessity for two people to be able to pass comfortably on them, and the fact that furniture will, at some time or other, have to be carried up or down. One person could with reasonable comfort use a stair 2 feet wide, but if two people are to be allowed to pass on the stairs, the width must be at least 3 feet, and 3½ feet is better.

The width necessary for the passage of furniture depends upon the sort of furniture which it is reasonable to expect will have to be taken up the stairs. Stairs which are open on one side, including open-well stairs, offer the best chance for getting large articles of furniture up, because they can usually be raised up over the hand-rails and newel posts unless they are very heavy.



Height Floor to Floor	No. Risers	Riser	Tread	No. Risers	L_1	No. Risers	L_2	M
8'-0"	13	7.38	10¼"	7	5'-1½"+W	6	4'-3¼"+W	....
8'-6"	14	7.29	10½"	7	5'-3" +W	7	5'-3" +W	4½"
9'-0"	15	7.20	10½"	8	6'-1½"+W	7	5'-3" +W	1'- 1½"
9'-6"	16	7.13	10¾"	8	6'-3¼"+W	8	6'-3¼"+W	1'-11¼"

Fig. 90A. Dimensions for Wide L Stair
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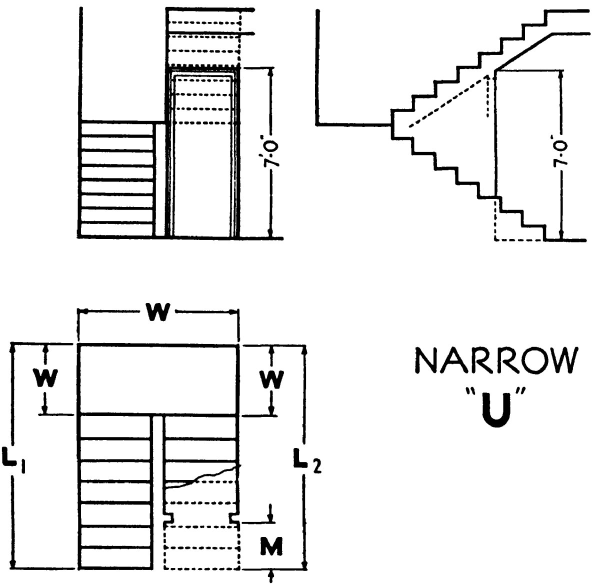
Stairs of the "narrow U" type or closed string stairs are the worst from the point of view of furniture moving, especially if there are any winders. Fig. 86 shows a narrow U type of stair in plan and section, and illustrates how the article of furniture must be maneuvered to get it up the stairs. Fig. 87 gives a table showing the average sizes of many articles and the clear width inside of all obstructions (such as newels, etc.) required for both narrow and wide U-type stairs under different headroom conditions in order to get each article up the stairs. The widest stairs are required for the passage of such furniture as pianos, tables, desks, etc., which are not likely to be taken upstairs in houses. A dresser is the most difficult article of bedroom furniture to handle. A wide landing and a wide



Height Floor to Floor	No. Risers	Riser	Tread	No. Risers	L_1	No. Risers	L_2	M
8'-0"	13	7.38	10¼"	7	5'-1½"+W	6	4'-3¼"+W	......
8'-6"	14	7.29	10½"	7	5'-3" +W	7	5'-3" +W	4½"
9'-0"	15	7.20	10½"	8	6'-1½"+W	7	5'-3" +W	1'- 1½"
9'-6"	16	7.13	10¾"	8	6'-3¼"+W	8	6'-3¼"+W	1'-11¼"

Fig. 90B. Dimensions for Narrow U Stair
Reproduced by Courtesy of Architectural Record

upper hallway are a great help and make possible the building of a somewhat narrower stair.

Correct Dimensions for Stairs. In Figs. 88A, 88B, 89A, 89B, 90A and 90B are presented 6 tables, each with an accompanying diagram, which were published in the *American Architect* magazine, showing stairs of 6 different types. For each type, governing dimensions are given with different floor-to-floor heights, which will greatly simplify the task of laying out stairs. The width, W, would have to be determined independently, to suit the circumstances under which the stairs would be used.

In the diagrams and tables the letter L_1 indicates the length in

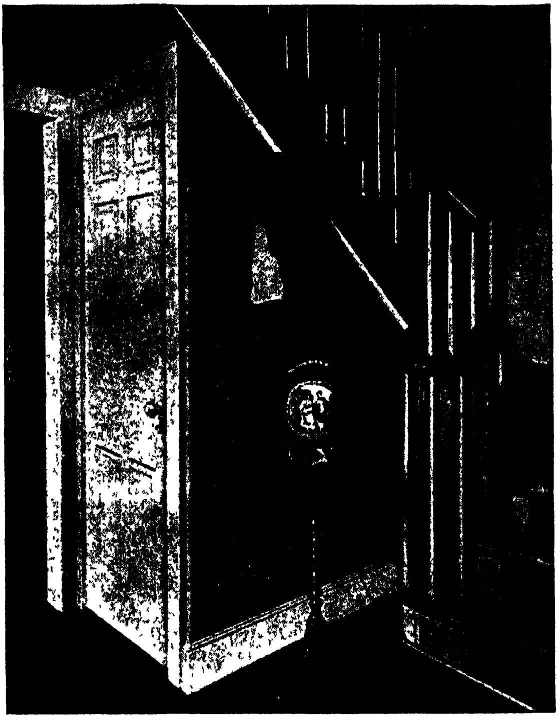


Fig. 91. Open String Stair with Door under the Soffit
Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

plan for the run of straight stairs for the given floor-to-floor heights and dimensions of risers and treads. The letters L_2 and L_3 show the widths required in plan at right angles to L_1 when the stair is an **L**-shaped or wide **U**-shaped stair. The letter M shows the distance in plan (from the head or from the foot of the stairs) which is required to allow a 7-foot door to be placed under the soffit of the stair, as shown in Fig. 91, for access to a closet under the stairs or for any other such purpose.

AN EXCELLENT EXAMPLE OF GOOD DESIGN IN STAIR MATERIAL

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

CHAPTER IV

BUILDING THE STAIRS

Procedure for Building Stairs. Having determined, by means of the diagrams or by means of one of the rules, the dimensions desired for treads and risers and the length of run for the stairs (or perhaps these essentials were given by an architect's drawing) the next step is building the stair in place. Suppose that the framework of the building has been erected and that a rough wellhole has been prepared in the joisting of the floors and properly trimmed as shown in Fig. 80.

However carefully the framework may have been built and however carefully the stair may have been laid out on a drawing board beforehand, slight mistakes may have occurred; in any case the stairs must be arranged to suit the actual conditions as determined by the existing framework. To do this, make a *rod* (out of 1½″ x 1½″ dressed stuff) long enough to reach from one floor level to another. This is sometimes called a *story rod.* Stand this rod up perfectly plumb in the stair well and mark on it the levels of the finished floor surfaces at bottom and at top of the flight of stairs, as shown in Fig. 92. If there are to be 12 risers, divide the distance between the above-mentioned marks into 12 exactly equal parts, each one of which will be the height of one riser from top of tread to top of tread. Make another set of marks on the rod just below the first marks, the distance between the two sets of marks being just equal to the finished thickness of the treads. The second set of marks will then represent the top surfaces of the steps of the cut strings.

Make another rod a little longer than the run of the flight of stairs and mark off on it the exact available horizontal distance from the face of the lowest riser to the face of the highest riser in the flight of stairs. If there are to be 12 risers, divide the distance between these marks into 11 (one less than 12) exactly equal parts, each one of which will be the width of one tread from face to face of the finished risers. Now make other marks to represent the backs of the risers, allowing for their thickness, and these last marks will represent the faces of the steps of the cut strings.

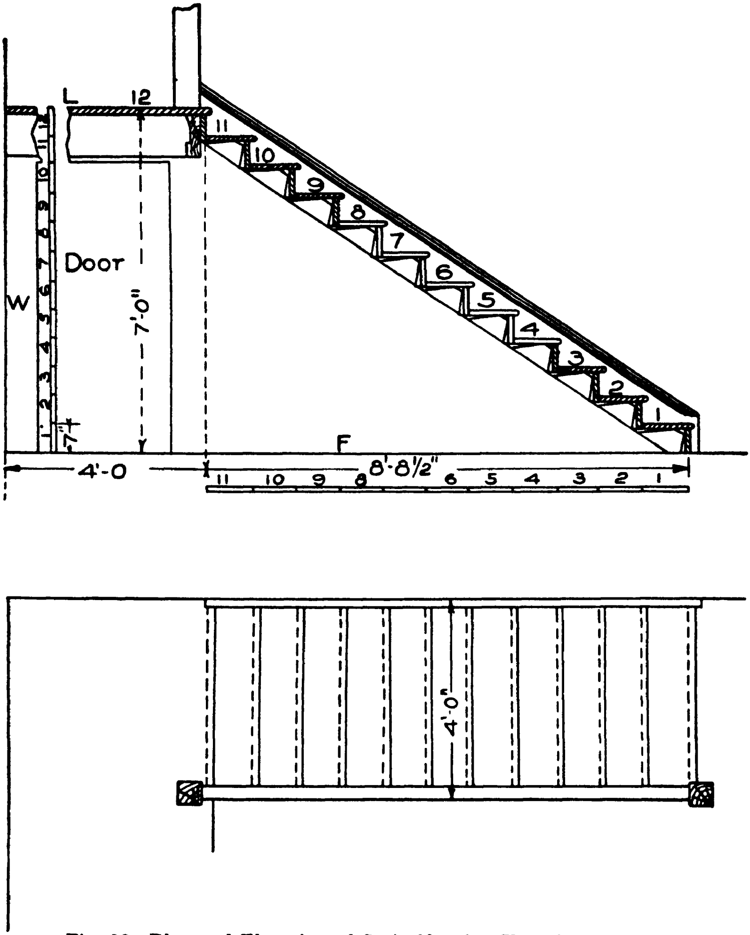


Fig. 92. Plan and Elevation of Stair Showing Use of a Story Rod

With the information furnished by these two rods as to the width of tread and height of riser, a pitch-board can be prepared as explained in connection with Fig. 23 and the cut strings can be laid out and made as shown in Fig. 26. The pitch-board must be made very carefully from dry hard wood about ⅜ inch thick. One end and one side must be perfectly square to each other. On the one side, the width of the tread back to back of risers is set off, and on the other is set off the height of the riser from underside of one tread to the underside of the next tread. The wood is sawed on a line connecting the two points. On the longest side of the triangular piece thus formed, a gage piece is fixed as was shown in Fig. 25.

The length of the strings can be determined by applying the pitch-board to the lumber as explained in connection with Fig. 26 and marking off the lines of the treads and risers on the side of the string as shown in Fig. 26, moving the pitch-board along the edge of the string as many times as there are treads in the flight of stairs. After the center and outer cut strings have been marked out and cut, they can be used as templates for marking off the string which is to go against the wall and which is called the *wall string*. The wall string does not have the triangular pieces (marked out with the pitch-board) cut out of the string because the wall string has its upper edge projecting above the upper surface of the treads as shown in Fig. 92. For this reason the wall string is made wider than the cut strings. Cut strings may be 11 inches wide, but wall strings would be 12 inches wide or wider.

The result is the *housing* of the wall strings to receive the ends of the treads and risers as explained in connection with Fig. 44. After the positions of the undersides of the treads and the backs of the risers have been marked out on the wall string by means of the pitch-board and the cut string, the treads should be numbered to correspond with the story-rod as shown in Fig. 92. Then other lines should be drawn on the side of the wall string showing the position of the tops of the treads, the faces of the risers, and the thickness of the treads and risers. This can be done by using thin strips of hard wood cut to width equal to the thickness of the treads and risers. These strips of hard wood will represent, and can be used to determine, the width of the housings to be cut in the side of the wall string. With these strips and allowing for the wedges under the treads and behind the risers, as shown in Fig. 44, the exact width of the housings can be found and they can be cut out to a depth of about 5/8 inch. When the strings have been cut, they can be erected in place as shown in Fig. 27 and the finished treads and risers can be fitted to them later, being wedged, glued and blocked on the underside or back as shown in Figs. 92 and 44.

Sometimes the flights of stairs are completely finished away from the building from measurements carefully made. In this case care must be taken to make sure that they can be brought into the building and put up in position without any trouble.

In taking the measurements at the building, it is essential that the exact position allowable for the first and last risers be ascertained and noted, and that the height of the story or the distance from the lower floor to the landing where the stair is to be placed should also be noted.

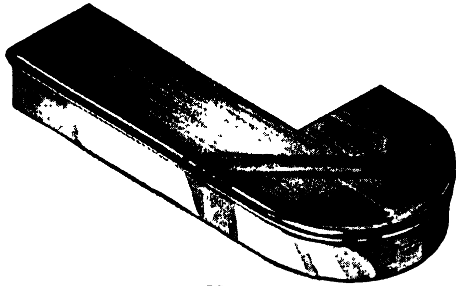
If an architectural plan is not available, a sketch plan should be made of the hall or other room in which the stairs are located, including surrounding or adjoining parts of the room to a distance of 10 or 12 feet from the place assigned for the foot of the stair. All the doorways or windows which can possibly come in contact with any part of the stair must be noted.

STAIR FINISH

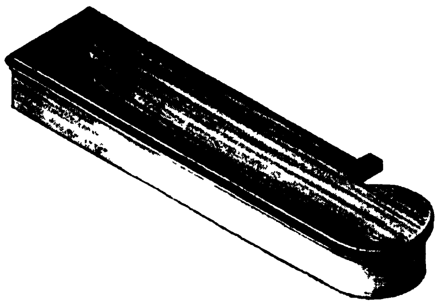
The parts of a staircase which are visible to the eye in a finished structure are what is known as the *stair finish* as distinguished from the concealed supporting parts which are called the stair framing. The stair finish consists of the treads and the risers in the body of the stair and a *starting step* at the bottom, together with newel posts at bottom, at top and at landings, and the balusters and handrails. All of these parts may be bought ready-made from wood-working mills in a variety of designs and in a broad selection of different woods, such as white pine, yellow pine, oak, birch, and walnut. Pine is not often used for stair treads; they are usually of birch or oak.

Treads and Risers. Fig. 50 shows treads and risers, cove mold, etc., as they can be bought from the mills. The different pieces come packed in bundles and are put together at the building. The special tread shown at *C-9625* in Fig. 50 is a *landing tread* and is used at the front of the landing as at *A* in Fig. 52. This one is rabbeted so as to be thinner at the back than it is at the front because the landing is treated just like a floor and finished on top with ordinary hardwood flooring which may be $^{13}/_{16}$ inch thick while the stair treads are $1^{1}/_{32}$ inches thick. Therefore the landing tread is made so that the front will have the same thickness and appearance as the other stair treads and the back will have the same thickness as the flooring of the landing.

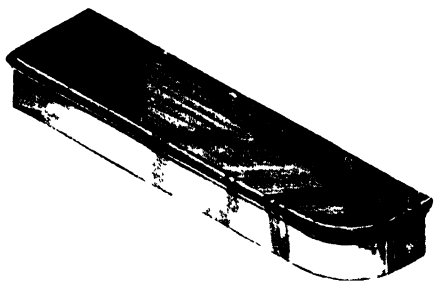
The starting step at the bottom of an open staircase is usually different from the other steps and it may be any one of several different shapes at the open end, as shown in the illustrations of staircases.



M-880



M-881



M-896

Fig. 93. Three Styles for Starting Step of an Open Stair

Courtesy of Morgan Company, Oshkosh, Wisconsin

Fig. 93 shows different stock patterns which can be bought from the mills.

The step marked *M-896* is suitable for a stair such as is shown in Fig. 6, *M-881* is suitable for Fig. 15, and *M-880* for Fig. 3.

Newels. Newel posts can be of any design to suit the fancy of the architect or the stair builder if made to order, but a great variety are available from stock at the mills. The modern staircases have, as a rule, much smaller newel posts than old-fashioned ones, except in the case of very grand staircases of the English type. The smaller newel posts are generally turned out of the solid, while the bigger square ones are built up and are hollow inside as shown in Fig. 94, which is a view looking into the bottom of one of them. The various illustrations of stairs included elsewhere in this book show different

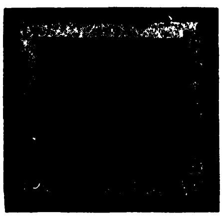


Fig. 94. Square Newel Put Together with Miter Joints
Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton Iowa

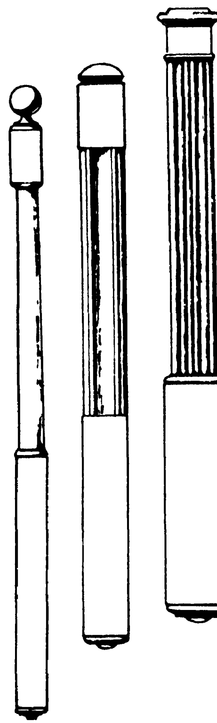


Fig 95. Three Stock Patterns for Newels
Courtesy of Morgan Company, Oshkosh Wisconsin

designs of newel posts suitable for use at the start of a staircase. At the landings, the newel posts are usually made with drops as shown in Fig. 65. These are called *landing newels* as distinguished from *starting newels.* Fig. 95 shows three designs available from stock.

Most starting newels and landing newels have decorative turned or carved tops which project above the top of the handrail. Many modern staircases, however, have newels which are somewhat like glorified balusters, because the handrail passes right over the top of the newel post, which is like a baluster but bigger, and fits into a small flat molded cap that matches the handrail and in many cases forms a part of the handrail. Fig. 96 shows four of these flat, molded, newel caps in the upper part of the figure and Fig. 97 shows two newel posts suitable for use with these caps. The small dowel at the top of these newels fits into a hole in the cap. Newels of this sort are shown in several of the illustrations.

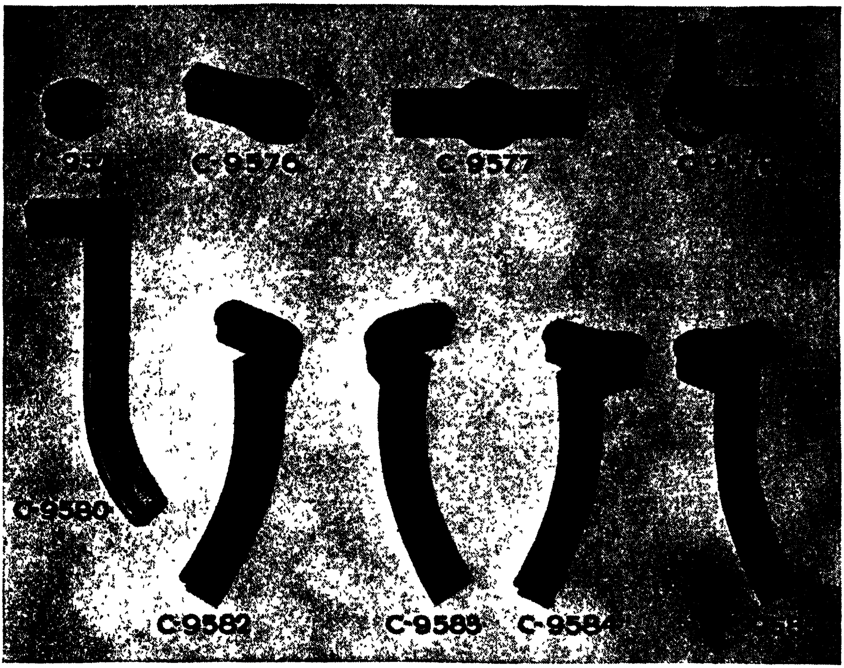


Fig. 96. Caps for Newels and Gooseneck Handrails
Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

Balusters. The ordinary balusters are of great variety and may of course be turned to order to any desired design, but the mills carry an excellent selection in stock. These vary from plain balusters $1\frac{1}{16}$ inches or $1\frac{5}{16}$ inches square or plain round balusters of similar dimensions which are used for delicate Colonial type stairways, to heavier balusters turned out of $1\frac{5}{8}$-inch squares or even 2-inch squares. Fig. 98 shows a number of stock balusters. The heavier ones such as *C-9265* are for balustrades such as that shown in Fig. 6 and so are shorter than the others since they sit up on the stringer instead of the treads. Light balusters are often used three to a tread.

Fig. 97. Newels for Use with Newel Caps

Courtesy of Morgan Company, Oshkosh, Wisconsin

Fig. 99. Lower Ends of a Group of Balusters Showing Dowels which Fit into Holes in the Tread of Bullnose Step

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

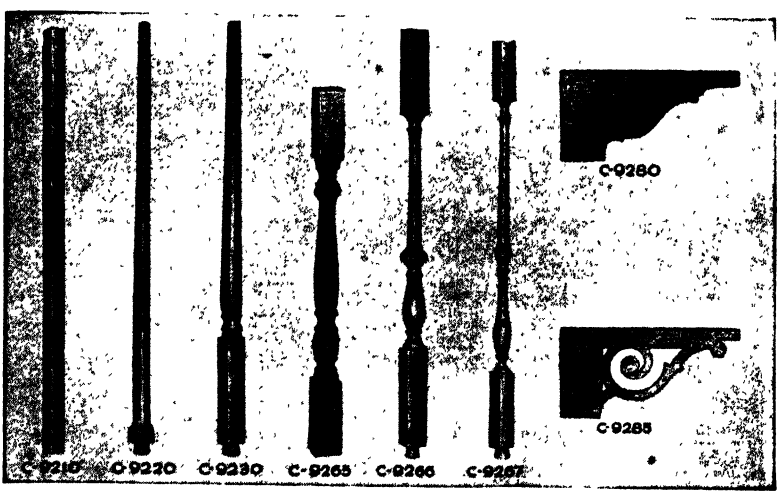


Fig. 98. Stock Patterns for Balusters and Brackets

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

Fig. 15 shows a type of starting newel often used with Colonial type staircases where the balustrade is carried all around the small starting newel forming a spiral. The handrail is flattened out and carried around in a horizontal spiral on top of the balusters. Fig. 99 shows a view of the lower end of a group of balusters of this kind and the curved end of the bottom step and illustrates how the balusters and newel can have dowels worked on their lower ends which fit into holes cut in the tread of the bottom step. The balusters are then said to be double-pinned to the tread.

Brackets. Fig. 98 also shows at *C-9280* and *C-9285* stock brackets of different designs. Fig. 31 shows how such brackets are used.

Handrails. Practically every inside stair has a handrail of one sort or another as shown in the various illustrations of stairs. If there are newel posts at the start of the flights both up and down and at the corner of each landing, or at each turn of the stairs where winders are located, the installation of the handrails presents no serious problem. They can be purchased at the mill in straight lengths either in stock pattern or built to order to any special design, and all the stair builder has to do is to fit them to the newel posts.

If the newels are of the types shown in Figs. 91 and 97 (designed so that the handrail passes over the top of the newel) and if there are landings or winders in the stairs where the newels occur, as shown in Fig. 91, bent handrails called *goosenecks* will be required to allow for the steep rise at the inside of the staircase at the landings or winders. The lower part of Fig. 96 shows three different types of these gooseneck handrails which can be used with newels of the type shown in Fig. 97. The gooseneck shown at *C-9580*, Fig. 96, is illustrated in use as part of the handrail shown in the upper part of Fig. 91. The other four goosenecks shown in Fig. 96 are applicable for use at the top of a staircase where the handrail is to continue around the landing as a level rail at right angles to the run of the stair as in Fig. 139 but passing over the top of a newel of the type shown in Fig. 97. They can also be used at winders. The newel at the extreme right of Fig. 91 at the first turn of the stairs shows gooseneck *C-9584* of Fig. 96 in place in the stair railing. As will be seen in both illustrations, this gooseneck has a newel cap incorporated in it.

If the newel posts are of the type shown in Figs. 95 and 100, straight sections of handrail are used and they are fitted against the sides of the newel posts. There are generally only two cuts to make, one at the top of a slope where the handrail has to be fitted to the top newel, and the other at the bottom of a slope where the handrail has to be fitted to the lower newel. Fig. 100 shows both cases.

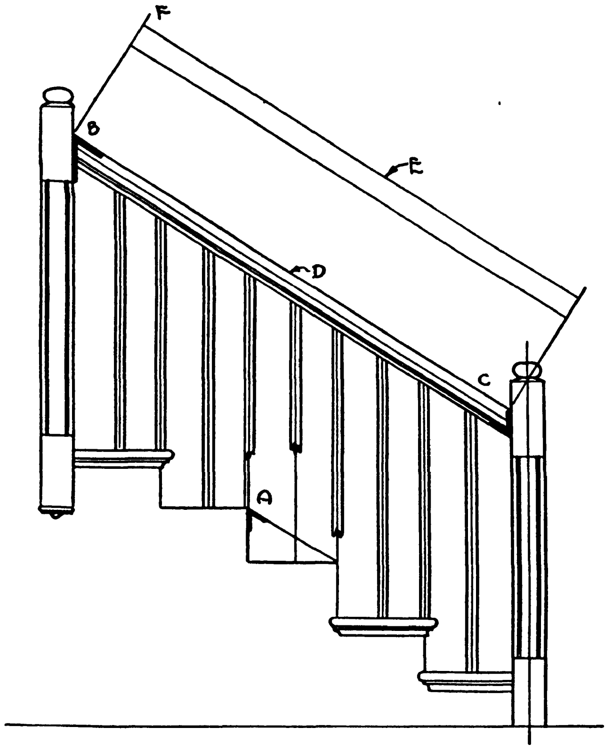


Fig. 100. Elevation Showing Handrail Fitted to Newels

The face of the newel which receives the handrail is nearly always vertical, while the handrail, except where it occurs at a level landing, is always sloping. To fit the sloping handrail to the vertical or upright face of the newel requires a cut on the handrail which is at an angle with the center line of the handrail, this angle being called a bevel. The top of the handrail is always shaped to fit the hand, but the under side of the handrail is nearly always a plain surface to receive the top ends of the balusters. See Fig. 101.

Plain surfaces such as the face of the newel post and the underside of the handrail are called *planes,* and are parts of much larger imaginary plain surfaces or "planes" extending in all directions and in which they are said to lie. According to Webster's Dictionary a "plane" is "a surface, real or imaginary, in which, if any two points are taken, the straight line which joins them lies wholly in that surface; or a surface, any section (intersection) of which by a like (similar, Plain) surface, is a straight line."

Now the underside of the handrail lies in one plane, which is a sloping or inclined plane, and the face of the newel post lies in another plane, which is a vertical or upright plane. Where they meet, that is, where the end of the handrail meets the face of the newel post, these two planes intersect each other in a straight line, which in this

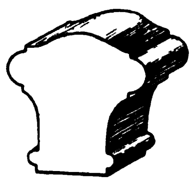


Fig. 101. Cross Section of Handrail Showing Top Shaped to Fit the Hand and the Bottom Flat to Receive the Balusters

Courtesy of Morgan Company, Oshkosh, Wisconsin

case is horizontal. The face of the newel post forms a part of the vertical plane and the end of the handrail, when cut to fit against it and in place, also forms a smaller part of this same vertical plane, and the angle between this vertical plane and the sloping or inclined plane of which the underside of the handrail forms a part is the bevel.

The faces of the risers of the steps lie in a series of vertical planes parallel to the plane in which lies the face of the newel post, and the top surfaces of the treads of the steps lie in a series of horizontal planes parallel to the floor surface. These surfaces or planes intersect each other in a series of horizontal lines at the nosings of the steps as shown at *A,B,C,D,E,* Fig. 102, and these horizontal lines themselves lie in an imaginary inclined plane which follows the slope of the stairs. If you were to take a very large sheet of glass and lay it on the slope of the stairs so that it rested on the nosings of the steps, it might be said to represent this imaginary sloping plane.

Since in a straight flight of steps (with no winders) all the risers are of the same height and all the treads are of the same width (which remains the same throughout their length), the imaginary sloping plane in which the nosings all lie is said to be inclined in one direction only; that is to say it will intersect any horizontal plane, such as the floor or any stair tread, in a horizontal line, and all these horizontal lines will be parallel to each other.

This plane will intersect any vertical plane parallel to the risers of the steps, such as the face of the newel post, in a horizontal line, but its intersection with a vertical plane at right angles to the faces of the risers, such as the enclosing walls or the plane in which the balusters lie, will be a sloping line. Now, because the handrail is

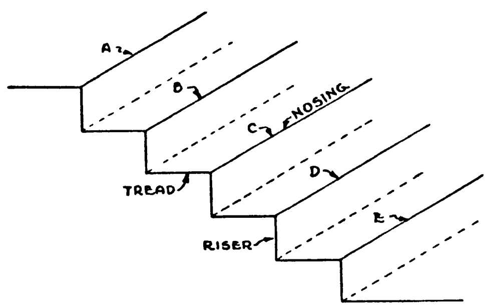


Fig 102 Isometric of Steps Showing Planes of Treads and Risers Intersecting in Lines of Nosings

at the same height above each tread at the face of the riser, it follows that the inclined plane in which the underside of the handrail lies must be parallel to the sloping plane in which all the stair nosings lie, and any vertical plane parallel to the faces of the risers (such as the plane of the vertical face of the newel post), will make the same angle with the plane of the underside of the handrail as the faces of the risers make with the inclined plane in which the stair nosings lie. This is illustrated in Fig. 100. This angle, or bevel, is given by the pitch-board for the stairs which, as was explained before and illustrated in Fig. 23, is the right-angled triangle formed by the riser and the tread of the stair with the inclined line joining the two nosings as the hypotenuse. See *A* in Fig. 100.

The triangle is really formed by the lines of intersection of three planes with a fourth plane. The three planes are: first, the vertical plane in which the face of the riser of the step lies; second, the horizontal plane in which the tread of the step below lies; and third, the inclined or sloping plane in which the nosings of both steps lie. The fourth plane, which is intersected by the other three to form the right-angled triangle of the pitch-board, is the vertical plane of the wall or partition against which the stairs are placed, or any vertical plane parallel to this, such as the vertical plane in which the balusters lie. The lines forming the right-angled triangle lie in the fourth or vertical plane.

The real lines forming the triangle of the pitch-board in Fig. 100 also actually lie in the plane formed by the page of your book on which the illustration appears. If you lay your book down flat on the table open to this page, the page will of course be really in a horizontal position, that is, the page will form part of, or *lie in*, a horizontal plane, and the lines of the triangle in the illustration also really lie in the same horizontal plane. The question may arise as to how it is that lines which form a triangle which is actually in a vertical plane can be illustrated by lines in a figure which are really in a horizontal plane. This question can be answered as follows: if you will raise your book into an upright position without moving the bottom edge of the page off the table and in fact without moving the bottom edge of the page at all, you will find that the lines of the illustration in Fig. 100 are now really in a vertical plane just as are the actual lines in which the riser and tread of the step intersect the vertical plane formed by the wall or by the balusters. The bottom edge of the page is the line in which this vertical plane intersects the horizontal plane of the table top. Now, without moving the bottom edge of the page from its position on the table, lower the page to its first position flat on the table. What you have done is to revolve, or turn, the vertical plane represented by the page about its bottom edge as an axis into a horizontal position. In other words, you have revolved the vertical plane of the page about the line of its intersection with the horizontal plane of the table top from its vertical position into a horizontal position in the plane of the table top. This shows that you can imagine any plane, together with all the lines which lie in it, as being revolved about the line of its intersection with another plane into any position necessary. This is done so that you may imagine yourself looking directly at the lines in the plane, and so that you see these lines in their true length and can actually measure them. Then the angle between any two of these lines will appear in its true form and size.

Take your sharpened pencil and hold it up in a horizontal position in line with your eye so that you are looking directly at the side of it. Let the pencil represent a straight line which you are now seeing in its full or "true" length. Now turn the pencil around, still keeping it horizontal, until you are looking straight at the sharpened end of it and shut one eye. All you will now see of the pencil or line is a black dot, although it is really just the same length as before. If you now turn the pencil very slowly around, back to its original position, it will appear to have a number of different lengths varying from the black dot, which has no length at all, to the full actual length of the pencil, depending only upon the position of the pencil with relation to your eye. This illustrates the fact that unless you are looking squarely at the plane in which a line lies, the length of the line may appear *foreshortened* and not in its true length. Note also that a line may appear only as a black dot if you are looking directly at the end of it.

When looking at actual things, you can move about so as to get a true view of them, but when looking at a picture or illustration of a thing, your position with relation to the object is fixed and you must imagine the illustration being moved or turned inside out, as it were, to get an idea of its true dimensions. Thus a line may appear in a figure as a black dot or only as a point, and the side of an object or a plane may appear in an illustration as a line only, and it may be necessary to imagine the plane as being revolved about the line into a position where you are looking squarely at it, so as to see the lines which lie in the plane in their true length, and the angles formed by these lines as true angles. Thus the handrail in the plan view in Fig. 64 does not appear in its true length because in the plan view you are looking squarely down at a horizontal plane such as the planes of the floor and the treads of the steps, while the handrail actually lies in an inclined plane.

If you imagine a vertical plane just outside of the handrail, this plane would intersect the horizontal plane of the floor in the straight line *AB*. Imagine this vertical plane as being revolved about the line *AB* into the plane of the page, and you will have the elevation and a sectional view shown in Fig. 65 in which two lengths of handrail appear in true length and the angles between the handrail and the faces of the newel posts appear as true angles because this figure is a view looking squarely at those handrails.

To return again to the page of the book which was likened to a plane. When this plane is revolved about the bottom edge of the page into a vertical position, it still may not be in the proper or true position since there can be an infinite number of vertical planes. Any two vertical planes, however, which are not parallel to each other must meet in a vertical line and can be revolved about this line while still retaining their vertical position; also any vertical plane can be revolved about any vertical line in it and still retain its vertical position. For example you can revolve the page of the book in its vertical position about its bound edge just as you would turn the pages of the book. This would cause the plane of the page, together with all the lines or figures on that page, to take any desired position parallel to any fixed vertical plane being considered; for instance, the wall or partition, or the plane of the balusters of a staircase. Thus, for example, in Fig. 65 the line *CD* represents a vertical plane at right angles to the plane of the page and therefore appears only as a vertical line.

This plane *CD* contains the portion of the handrail and balustrade at the turn of the stairs, but this handrail does not appear in its true length or at its true angle with the faces of the newel posts. Imagine this plane *CD* revolved about the line *CD* just as you would turn a door on its hinges, until the plane comes into the plane of the page; you would then see the handrail in its true length and with its true bevels just as you see the other portions of the handrail in Fig. 65.

Figs. 65 and 100 present views of the *side* of the handrails and this is all that is needed in order to get the correct measurements and cuts for the rails, as long as they are straight (not curved) and as long as they are of such a design that they can be bought in lengths from a mill. Suppose, however, that the particular moldings desired cannot be procured from a mill and that a piece of the handrail must be made on the job or in the shop. Suppose that you must make the short piece of straight handrail shown in side elevation at *D* in Fig. 100. Such a piece of handrail is generally cut and fashioned from a plank as shown in Fig. 103, and after the plank has been cut to approximately the correct length, the next step is to somehow mark off on the broad side of the plank the maximum width of the handrail.

While the side view of the handrail seen in the elevation of the staircase with its balustrade shows the correct length of the rail, it gives absolutely no information regarding its width. To get this information, it is necessary to get a view looking *squarely* at the *top* of the handrail, not in plan, since this does not show the correct length, but a view that will show both the correct length and the correct width.

The top surface of the handrail (the surface on which one's hand rests when going up or down the stair) lies in a sloping plane which

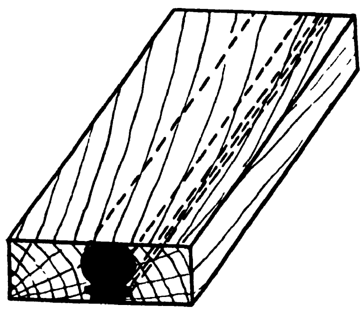


Fig. 103. Showing how Handrails Are Cut from Plank

intersects the plane of the page in the line BC, Fig. 100, and in order to get a true view of this plane and of the top of the handrail which lies in it, the plane must be revolved about its intersection with the plane of the page (the line BC) until it coincides with the plane of the page. This is done in Fig. 100.

Note that since the illustrations of Figs. 65 and 100 show *elevations* of the stairs, the pages must represent *vertical* planes and all lines which are perpendicular to, or at right angles to, such a plane (showing only as points in the figures such as the nosings of the stair treads) must be horizontal. Remembering that the page represents a *vertical* plane, hold the page in an upright position on the table. Take your sharpened pencil and hold it in a *horizontal* position with the point resting on the point B, Fig. 100. The pencil held in this position represents a horizontal line (since it is at right angles to the vertical plane represented by the page), and this line lies in the plane of the top of the handrail and is parallel to the nosings of the steps.

With the pencil still held in this horizontal position, imagine the plane in which it is supposed to lie (the plane which also contains the top surface of the handrail) as being revolved about the line *BC* (its line of intersection with the vertical plane represented by the page) into the plane of the page, and you will see that the horizontal line represented by the pencil would show as a line, *BF* Fig. 100, at right angles to the line *BC*, about which the plane is being revolved, and that this is true of every horizontal line lying in the plane which also contains the top surface of the handrail.

Since every line which runs squarely across the top surface of a handrail must be a horizontal line, it follows that the top surface of the piece of handrail being considered will appear in a true view as shown at *E* in Fig. 100, which shows the top surface of the handrail in its true width and length. If this were to be drawn out to full size on heavy brown paper and then cut out, the paper could serve as a pattern and could be pasted onto the plank or other piece of lumber from which the handrail is to be cut. Such a true view or pattern of the top surface of the handrail is called the *face mold* of the handrail and is used extensively for the purpose of cutting the handrails from planks. Of course, for a curved handrail the face mold is curved.

STAIR DESIGN FOR A RESIDENCE

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

CHAPTER V

CURVED HANDRAILS

The simplest form of curved handrail occurs only in level handrails, such as rails at the edges of landings, and where the rail is curved in the horizontal plane only, as at *A* in Fig. 104. A curved piece of handrail for this purpose is shown at *M-871* in Fig. 105 and is called a *quarter turn.* When the handrail is curved in a vertical plane only, the curved sections are called *easements.* Some of these

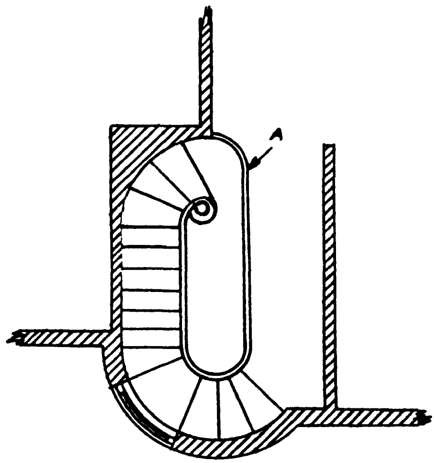


Fig 104. Plan Showing Curved Handrail

are shown in Fig. 105 at *M-869* and *M-870,* while *M-865* shows a straight gooseneck.

A gooseneck consists of a long vertical section of handrail with a short horizontal section at the top. Goosenecks are required where there are a number of winders in a staircase; this causes a quick drop at the inside of the turn. Fig. 91 shows a stair with goosenecks in the handrail and Fig. 96 shows a variety of curved goosenecks. In Fig. 96, *C-9580* shows a gooseneck similar to *M-865* in Fig. 105, but with a curved section at the bottom; *C-9582* and *C-9583* show left- and right-hand goosenecks with quarter turns at the top; while *C-9584* and *C-9585* show left- and right-hand goosenecks with quarter turn newel caps at the top.

C-9575 in Fig. 96 and *M-873* in Fig. 105 show small plain newel caps. In Fig. 105, *M-867* shows what is called a *volute with easement.* A handrail section of this kind is shown at the foot of the stairs in Fig. 106 and also in Fig. 15. The spiral part, or *volute,* is in

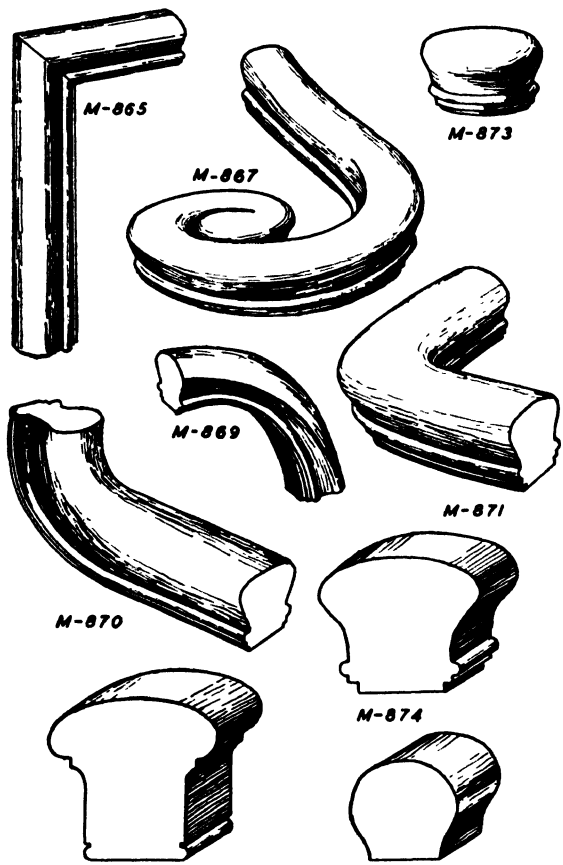


Fig 105 Shapes and Sections of Handrail
Courtesy of Morgan Company, Oshkosh, Wisconsin

a horizontal plane and the *easement,* sometimes called a *ramp,* connects this horizontal section to the sloping section of the handrail. In place of the volute there might be a square newel post with the stair widened out at the foot so that the handrail would connect into the side instead of into the back of the newel, as shown in plan in Fig. 133. In this case also the handrail might be so curved that it would be level or horizontal where it meets the side of the newel post.

Handrail sections of this kind are curved in both the vertical and horizontal planes and are called *wreaths.*

There are a number of different treatments of staircases which make curved handrails or portions of handrails necessary, and these may be listed as follows:

(A) Sometimes the designer wishes the stair to widen out at the

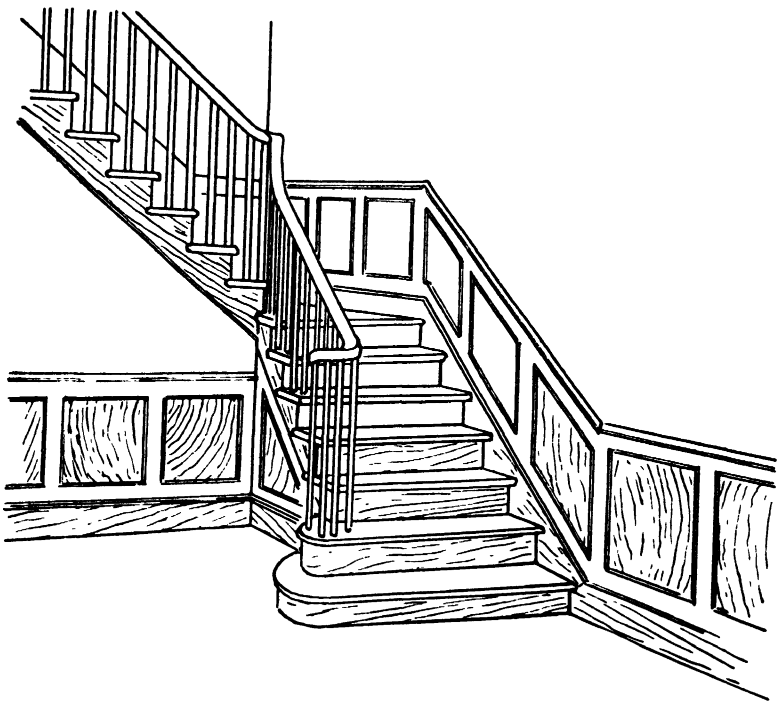


Fig. 106. Staircase with a Curved Handrail Forming Bottom Newel

bottom as shown in Fig. 106, each of the two bottom steps being somewhat longer than the step immediately above it. This gives the stair a more inviting appearance than it would otherwise have, but it calls for a curved section of the handrail at the foot of the stairs. This is the treatment of curved handrail most commonly met with in ordinary house construction.

(B) A staircase of a design met with only in the more spacious type of residence or in small public buildings is one where the stair winds about an elliptical or circular wellhole of moderate size with a landing at each floor level, such as is shown in Fig. 107. Here there are no newel posts, the handrail being continuous, leveling out at the landing around the stair well and following down around the slope of the stairs without a break.

(C) The type of geometrical stair shown in Fig. 67 with dancing winders arranged around a comparatively small cylinder.

In starting out to build any stair or the handrailing for any stair, the only information available to start with is the *plan* of the staircase, such as those shown in the various figures. The plans actually used on a job are blueprints and are usually drawn at a scale of

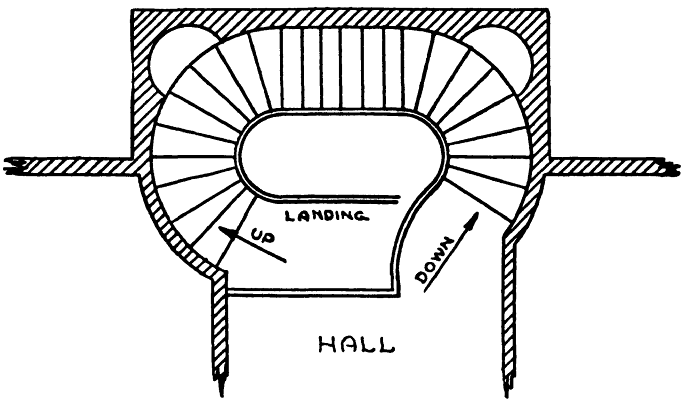


Fig. 107. Plan of Circular Stair with Continuous Handrail and without Newels

one-eighth inch to the foot or one-quarter inch to the foot. A plan of a handrail is a view of the handrail looking squarely down on it from above and this view therefore does not show the slope of the rail, nor does it show its true length or shape, except in the case of a level handrail at the edge of a landing which is perfectly level and does not slope, such as is shown at *A* in Fig. 104.

The plan view is really the projection of the handrail into a horizontal plane and since this does not give the true dimensions or shape of a sloping rail, the plan is taken as a starting point only and, with the assistance of other information regarding the size of the rail (obtained from the elevations and sectional drawings or blueprints), a drawing or diagram must be laid out either to scale or to full size, giving the true dimensions and shape of the top of the handrail. This is called the *face mold*. In dealing with a curved figure such as a handrail wreath, curved lines cannot be dealt with directly, so a start is made by considering the center line of the curved portion of the handrail, which is of course a curve in plan, and certain straight lines must be referred to which determine the shape or direction of the curve and its size.

For any curved line or figure, the straight lines which most easily

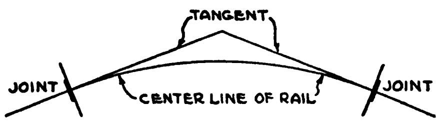


Fig. 108. Tangents to an Obtuse Angle Curve

can be dealt with to determine its shape and dimension are what are called the *tangents*. These are extensions of the center lines of the straight parts of the handrail which are joined by the curved portions. Such straight portions of the handrail occur at landings or at the straight flights of the stair. Fig. 108 shows in a plan view the straight lines tangent to an obtuse angle curve and Fig. 109 shows in

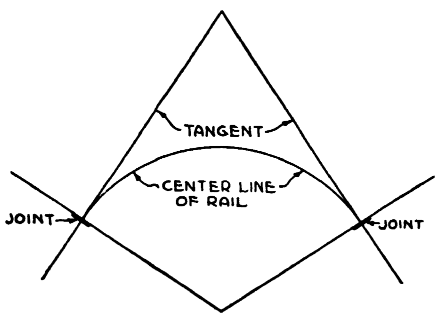


Fig. 109. Tangents to an Acute Angle Curve

a plan view the straight lines tangent to an acute angle curve. Fig. 110 shows in a plan view the straight lines tangent to a quadrant curve where the two tangents are at right angles to each other. The tangents are chosen for use in connection with the handrail curves because no matter how you look at the curve, whether in the plan view or in a view which shows its true size and shape, the tangents are *always* tangent to the curve at the points where the curve joins the straight parts of the handrail.

The plan views of the tangents shown in Figs. 108 and 109 do not give the true lengths of the tangents, nor the true angles between the tangents, any more than they give the true dimensions of the curve. However, if the tangents are projected into another plane so that their true lengths are obtained, and the true angle between them, the true curve and face mold of the handrail can be constructed from this true view of the tangents. This method is known as the *Tangent System* of handrailing.

In order to draw a true pattern for the curved handrail or wreath, called the face mold, you must be able to look squarely at the plan in which both of the tangents to the curve of the center line

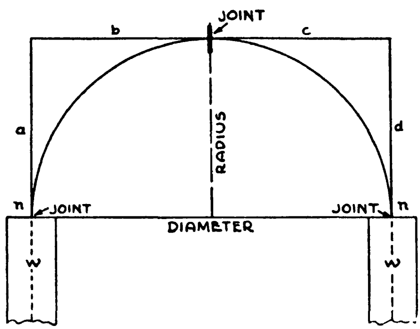


Fig 110 Plan Showing Quadrant Curve Having Tangents which Meet at Right Angles

of the handrail lie. Start with the horizontal plane of the plan view, but note that only in the case of a level handrail do both of the tangents lie in this plane, because in all other cases either one or both of the tangents are sloping. From the plan view combined with a knowledge of the height to which the curved handrail rises above the starting point in its curve, try to picture mentally, or in other words to visualize, the sloping plane in which the top surface of the handrail lies, together with its curved center line and the two tangents to that curve. Then the line must be found in which this inclined or sloping plane cuts the plane of our paper. Next, the sloping plane must be revolved around that line as an axis until it lies in the plane of the paper.

Let Fig. 107 be the plan view of a circular or geometrical stair starting off from a level landing and going up. The curved handrail is shown and at each end of the wellhole in this plan view it takes the shape of a quarter circle or quadrant. Fig. 111 is an enlarged plan view of the first quadrant where the stair starts up. The two tangents to the curve are shown at *ab* and *bc*. Since tangent *ab* lies wholly above the level landing and, in the plan view, does not cross any

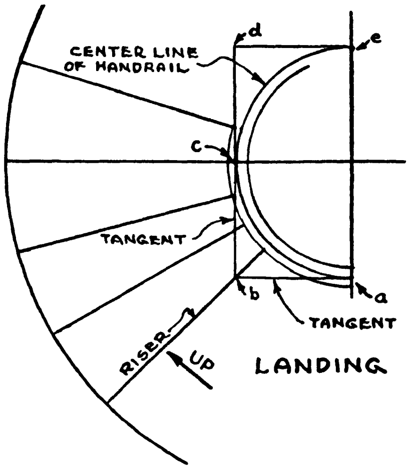


Fig. 111. Plan Showing Curve of Handrail and its Tangents

risers of the stair, this tangent must be level or horizontal. The other tangent, *bc*, is shown in the plan view as crossing 4 risers and, since the handrail must be kept at the same distance above all of the stair

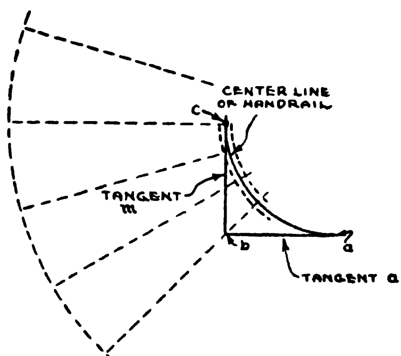


Fig. 112. Plan of Curved Handrail and Circular Stair

treads, it is evident that this tangent must slope and the plane which contains both tangents must also slope.

Fig. 112 shows a plan view of the lower (curved) part of the handrail and stair. All lines are dotted except the center curved line of the handrail top with its tangents. Point *C* is actually above point *b* a distance equal to the height of 4 risers, although this does not show in the plan view, therefore the handrail rises as it curves.

Fig. 113 gives an isometric view showing only the curved center line of the face mold of the sloping handrail and the two tangents to it. The plan view is shown dotted and the two tangents *ab* and *bc* are shown in this view in the horizontal plane. Tangent *ab* was found to be horizontal anyway, but tangent *bc* slopes upward from point *b* as it crosses the lines of the risers in plan. In Fig. 113 let the distance *ch* represent the combined height of four risers (about 29 inches). Let *h* be the point on the center line of the true curve

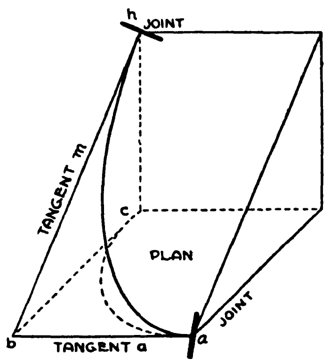


Fig 113. Plan Line of Handrail Projected into Oblique Plane Inclined to One Side Only

of the handrail where the sloping tangent *m* touches it. Then line *bh,* or tangent *m,* is an isometric view of the true tangent to the curve of the center line of the handrail. Returning now to the plan view Fig. 112, the triangular figure *bch* of Fig. 113 is comprised in the single line *bc.* The vertical line *ch,* representing the combined height of the four risers crossed by the sloping tangent (*bh* in Fig. 113, or tangent *m*), is represented in Fig. 112 by the black dot at *c.* The point *h* is at the same location as *c,* but about 29 inches straight up from the page above *c.* Now let us imagine that the vertical plane represented in Fig. 112 by the straight line *bc* and in Fig. 113 by the triangle *bch* and containing the vertical line *ch* and the sloping tangent *m,* is revolved to the left about the line *bc* as an axis (just as you would turn the page of a book) until it lies flat on the page before you. The result of this process is shown in Fig. 114A as the dotted triangle *bch*. The vertical distance *ch* is shown in this figure as a horizontal line and appears in its true length (to scale) while the sloping tangent *bh*, or tangent *m*, is also shown in its true length (to scale) in Fig. 114A.

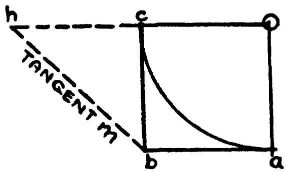


Fig. 114A. Diagram Showing Vertical Plane Revolved about Line *bc*

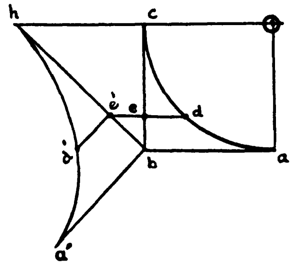


Fig. 114B. Diagram Showing How a True View of Curve of Handrail is Obtained

It is assumed that the sloping curved part of the handrail (the wreath) has its top surface (on which one's hand rests in going up or down the stairs and known as the *face mold*) lying in the same slop-

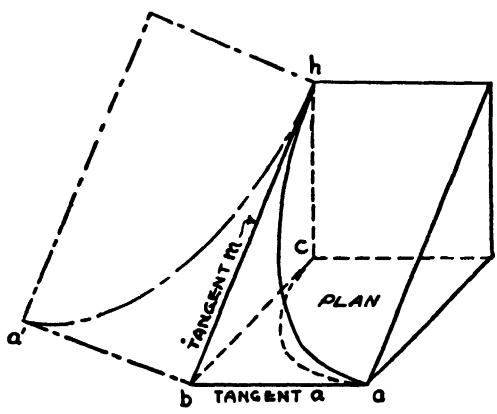


Fig. 115. Sloping Plane Revolved about Tangent *m*

ing or inclined plane in which lie the two tangents, tangent *a* and tangent *m*, as shown in Figs. 112 and 113.

To get a true view of the sloping plane imagine this plane (shown in Fig. 113 as *hba*) to be revolved around the line *bh* as an axis as illustrated in Fig. 115 (in the same way as you would open and turn over the cover of a book, with the line marked tangent *m* representing the binding) until it lies in the plane of the page; then everything on it, including the curve of the center line of the face mold, appears in its true dimensions (to scale).

Fig. 114A shows the first step in this process, which consists in revolving the triangle *bch* to the left about the line *bc* until it lies in the same plane with the lines *ab* and *bc*.

The next step in the process is shown in Fig. 114B where the true view of the curve *a'h* is drawn out. An explanation of the method employed to draw out this true view of the curve is as follows.

Since the line *ba* is actually horizontal, it must be at right angles to the vertical plane represented by the line *bc* and therefore at right angles to every line which lies in this vertical plane, including the line *bh* (or tangent *m*). Therefore, you have only to draw a line (*ba'* in Fig. 114B) at right angles to the line *bh* with one end at the point *b*, and to make this line equal in length to the line *ba*, and the two tangents are then shown in their true length and in their true relation to each other. Then a curved line joining the points *a'* and *h* in Fig. 114B and corresponding to the quadrant curve shown in plan view as the curve *ac* in Fig. 114A, will be a true picture (to scale) of the curve of the center line of the face mold of the wreath. This curve is drawn by taking advantage of the fact that any line parallel to line *ba* in Fig. 114A, and at right angles to line *bc*, is a horizontal line at right angles to the vertical plane and at right angles to every line in that plane, including the line *bh*; and moreover, each such horizontal line appears in its true length in the plan view in Fig. 114B, because it is horizontal and all horizontal lines appear in their true length in a plan view.

If such a line as *de* in Fig. 114B be drawn and extended until it cuts the line *bh* at *e'*, and is then extended at right angles to *bh* until the distance *e'd'* is equal to the distance *ed*, then this line *e'd'* is at the correct distance from the point *b*, and the line *d'e'*, drawn perpendicular to the line *bh*, is at the correct and true distance from the line *a'b* and parallel to *a'b*, and the point *d'* is a point on the true curve corresponding to the point *d* on the plan view of the curve. In this way any number of points may be established on the true curve of the center line of the face mold of the wreath and the curve may be drawn through these points and this curve will represent (to scale) the true length and curvature of the center line of the face mold. See Fig. 116. Moreover, lines drawn at right angles to this true curve at its ends and at the same time at right angles to the tangents as shown at *h* in Fig. 116 are the true lines of the joints or cuts at the ends of the wreath, so that it will fit square with the straight parts of the handrail which extend at each end of the wreath, one horizontal (along the landing) and the other sloping (following

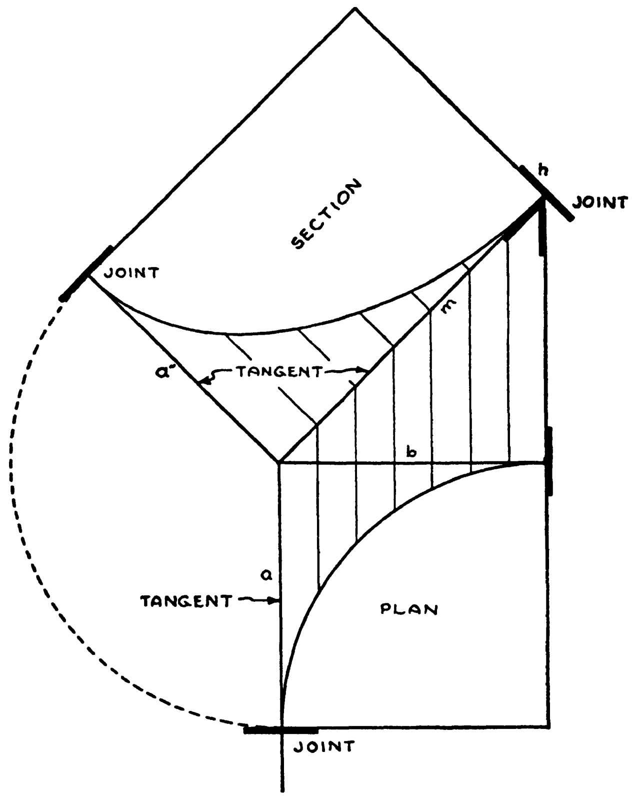


Fig. 116. Method of Laying Out True View of Handrail Curve from Plan View

the slope of the stairs). This curve, the true curve of the center line of the face mold of the wreath, is reproduced in Fig. 127, which also shows the face mold in its true width and length following the curve of the center line.

The width varies, depending upon the design of the handrail. What is shown in Fig. 127, is the pattern (to scale) for the handrail wreath. If this pattern is drawn out full size on heavy brown paper, it may be laid down on a piece of plank such as is shown in Fig. 117 and used to cut out the rough curved block of rectangular cross section (Fig. 118) from which the finished wreath will later be fashioned.

The plane in which the face mold of this handrail wreath lies, as shown in Fig. 113, is said to be inclined only in one direction with respect to the horizontal planes of the floor or the stair treads, since one of the two tangents which lie in the plane is horizontal.

It is suggested that you enlarge Fig. 116 on scrap paper to three times its present size, cut out the figure and fold the part marked *section,* along line marked *m,* until it sticks straight up from the page; then fold on line marked *b* until line *a″* coincides with line *a*

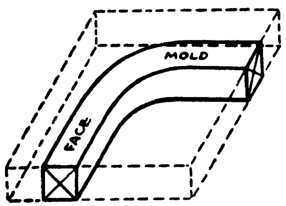


Fig. 117. Showing how a Rough Handrail Wreath May Be Cut from a Piece of Plank

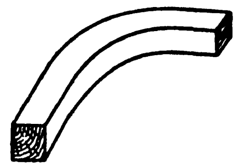


Fig 118. Rough Curved Handrail Wreath

(tangent *a*). Holding line *a* against *a″*, place the side marked "plan" on a horizontal plane. Gradually unfold the figure so that *m* lies in the horizontal. Note that, in doing this, the triangle revolved on line *b*. Next lay the rest of the paper flat. In doing this, the part marked "Section" was revolved about tangent *m* as an axis.

Now in the stair shown in plan view in Figs. 107 and 111 let us consider the curved part of the handrail immediately above the handrail wreath described in the preceding paragraphs and joining onto the upper end of it. This section of the handrail is shown in plan view by the second quadrant *ce,* Fig. 111, and the tangents to the plan view of the center line of the face mold are the lines *cd* and *de.* Fig. 119 is an enlarged view of this second quadrant, or plan view of the center line of the face mold of the handrail wreath, and it will be seen that the *two* tangents in this case *both* cross the lines of the risers in the plan view, which is proof that they *both* slope and that neither of them is horizontal. This condition is illustrated in the isometric view shown in Fig. 120 which shows the center line of the face mold of the sloping handrail and the two tangents to it.

The plan view is shown dotted and the two tangents, *cd* and *de*, are shown in this view in the horizontal plane. Tangent *cd* in this case is not really horizontal, but slopes upward from point *c* as it crosses the lines of the risers in plan. Tangent *de* also slopes upward from point *w*, but in a totally different direction, as it also crosses the lines of its risers in plan. In Fig. 120 let the distance *dw*

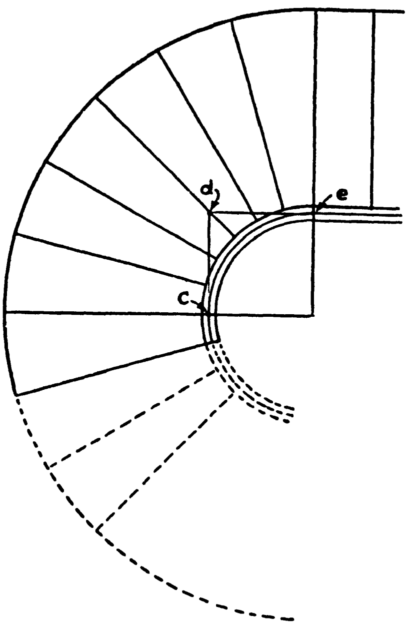


Fig. 119. Plan View of Center Line of Handrail Wreath

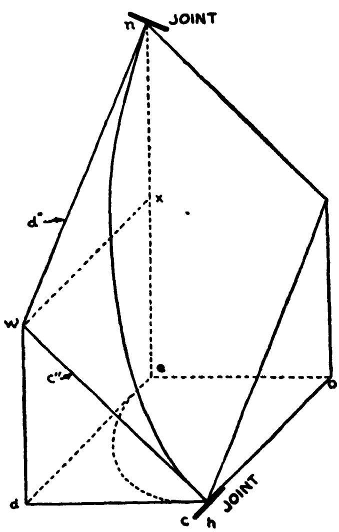


Fig. 120. Isometric View of Center Line of Handrail

represent the combined height of the three risers crossed by the tangent *cd*, and let the distance *xn* represent the combined height of the three risers crossed by the tangent *de*. Then the distance *exn* in Fig. 120 will represent the combined height of all the risers crossed by the two tangents *cd* and *de* and represents the distance through which the curve of the handrail rises in passing around the quadrant from *c* to *e*.

In this figure let *n* be the point on the center line of the true curve of the handrail where the actual sloping tangent, represented in plan view by the line *de*, touches it. In this case, however, the other tangent, represented in plan by the line *cd*, also slopes upward from the point *ch* and is shown by the line *c″* in Fig. 120 so that the lines *c″* and *d″* in this figure show in isometric view the two true tangents to the curve of the center line of the handrail. The true curve itself is shown in isometric view by the curved line in this figure. This curve, which is the center line of the face mold of the handrail wreath, lies in a plane which also contains both of the tangents and which is inclined or sloped in *two* directions with respect to the horizontal plane, as is shown by the position of the two tangents *c″* and *d″* in Fig. 120. To illustrate this, take a piece of ordinary letter paper and lay it flat on the table before you. Keep the edge nearest to you constantly in contact with the table and raise the paper up towards you into a sloping position without lifting this one edge off the table. This is the first slope. Now, without lifting the lower right-hand corner of the sheet of paper off the table or moving it from its position, raise the lower left-hand corner up off the table. This is the second slope. The sheet of paper in this final position represents a plane sloping in two directions with respect to a horizontal plane (the horizontal plane of the table top).

The face mold of the handrail wreath lies in this sort of a sloping plane as shown in the isometric view of its center line in Fig. 120. The problem is to get a true view of this plane with the two tangents and the curve of the center line of the face mold in it, and all you have to start with is the plan view shown in Fig. 119 and information regarding the number and heights of the stair risers. It must be realized that the curved line *cn* (or *hn*) in Fig. 120 shows in *isometric* view the curve of the center line of the handrail wreath which is shown in plan view in Fig. 119 from point *c* to point *e*, but that an isometric view is not a direct or true view of the curve and could not be used as a pattern from which the actual curved handrail wreath could be made. Patterns of this kind are shown to small scale in Figs. 127 and 129, where they are called "face molds" and the only way in which they can be made is to draw out a true view of each of the planes in which the face molds lie. Figs. 121 to 125 and the explanations which accompany them show the successive steps by which the information available (from the plan view [Fig. 119] and from knowledge of the heights of the risers) is used to draw out a true view of the handrail curve and of the plane in which it lies.

In the plan view, Fig 119, the vertical plane of the triangle *cdw* of Fig. 120 is represented by the line *cd* and the vertical plane of the trapezoid *denwd* of Fig. 120 is represented by the line *de*. Since these are both vertical planes, they intersect in the vertical line *dw* in Fig. 120, and the smaller vertical plane of the triangle *cdw* can be revolved about the line of intersection, *dw*, until it coincides with

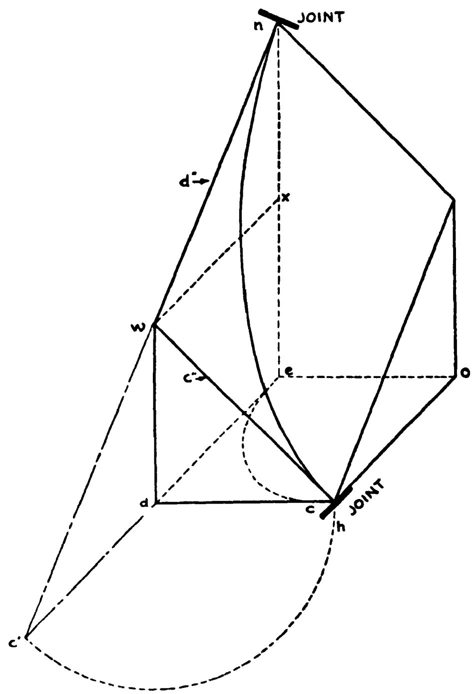


Fig. 121. Isometric View Showing Plane **wdc** Revolved into the Vertical Plane

the larger vertical plane of the trapezoid *denwd*. It is shown in isometric view in Fig. 121 by the triangle *dwc′*. This is the first step.

In Fig. 121 the vertical plane of the triangle *c′en* is represented in the plan view, Fig. 121, by the line *c′de*. As it is a vertical plane, and the line *c′de* is a horizontal line, the horizontal plane *cdeo* can be revolved about this line *c′de* down into the vertical plane where it is shown isometric in Fig. 122A as c_1deo_1.

Another way of laying out these planes is to revolve the vertical plane of the triangle *c′en* of Fig. 121 about the horizontal line *c′de* down into the horizontal plane of the plan. This is the second step and is shown in isometric view in Fig. 122B and in plan view in Fig. 123B.

The first step was to revolve triangle *wdc*, Fig. 121, about line *wd* as an axis into position *wdc′*. The second step was to revolve either the vertical plane *c′ne*, Fig. 121, or the horizontal plane *cdeo* (in this same figure), about the horizontal line *c′de* (in which the two planes intersect) until the two planes are in line with each other

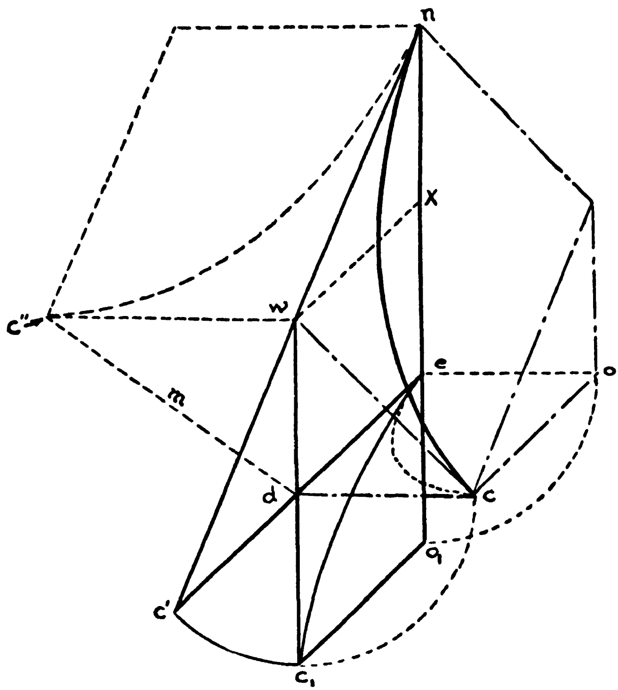


Fig. 122A. Isometric View of All Planes Revolved into the Vertical

as shown in Fig. 123A or 123B, and in isometric view in Figs. 122A and 122B.

Figs. 123A and 123B are alike except that in Fig. 123A line *nxc* is shown vertical, while in Fig. 123B this line is shown horizontal and all the other lines and letters are arranged to correspond. If you revolve Fig. 123B about the point *d* to the right, or as the hands of a clock turn, you will get Fig. 123A. Since line *nxe* is actually vertical because it represents the difference in height between point *c* and point *n* in going up the winding stairs (see Fig. 126) it is necessary to work with the diagram in the position shown in Fig. 123A.

In order to make this layout, take the plan view of the quadrant *cdeo,* Fig. 123A, and extend the tangent line *de* until the distance *c′d* is equal to the tangent distance *dc*. This can be done by placing one point of the dividers on the point *d* and the other point of the dividers on the point *c* and swinging the point *c* around to the point *c′* while keeping the point *d* stationary. Then draw *dw* at right angles to

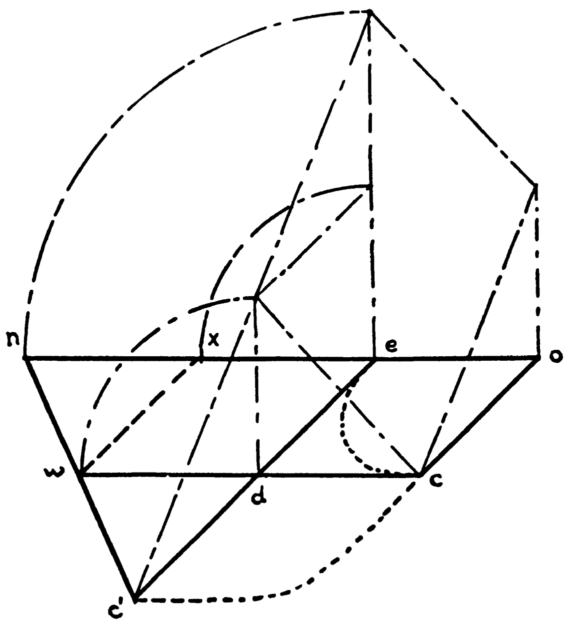


Fig. 122B. Showing All Planes Revolved into the Horizontal Plane

the line *c′de* and make its length (to scale) equal to the height of the three risers crossed by the tangent *cd* (about 21 inches). This will locate the point *w*. Then draw *en* at right angles to the line *c′de* and make its length equal to the height of the three risers crossed by the tangent *cd,* plus the height of the three risers crossed by the tangent *de,* or, in other words, equal to the combined height of all the risers crossed by the two tangents (about 42 inches, to scale). This will locate the point *n*.

Having located the points *c′* and *w* and *n,* the line *c′wn* can now be drawn. The distance *c′w* shows the true length of the tangent represented in the plan view by the line *cd*. The distance *wn* shows the true length of the tangent represented in the plan view by the line *de*.

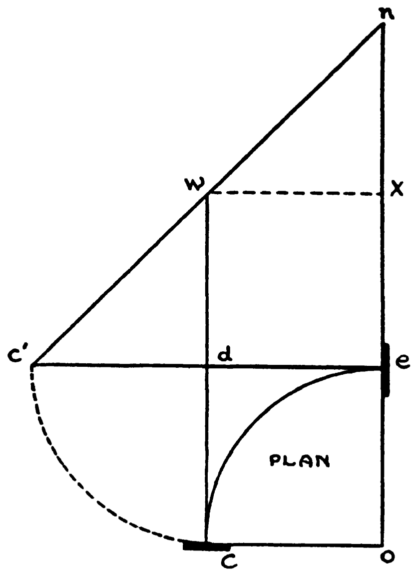


Fig. 123A Showing All Planes Revolved into the Vertical Plane

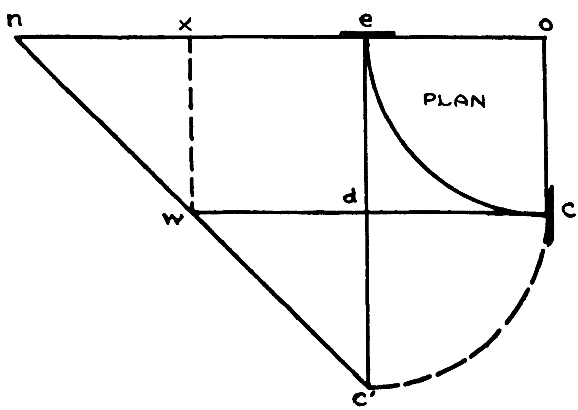


Fig. 123B. Showing All Planes Revolved into the Horizontal Plane

The two tangents to the curve of the center line of the face mold of the handrail wreath are shown in Fig. 123A in their true lengths, but *not* in their true relation to each other. Fig. 120 shows in isometric view that the two tangents (c'' and d'' in this figure) make an angle with each other, and it appears from this figure that the angle between them is not a right angle. In order to get a true view of this angle and of the curve of the face mold, it is necessary to imagine the plane *cwn,* in which they lie (Fig. 120) as being revolved about the line *wn* as axis, up and over to the left (see Fig. 122A) until it lies in the same plane as the lines, *dw, wn,* and *exn,* and then to imagine that the two planes together are revolved about

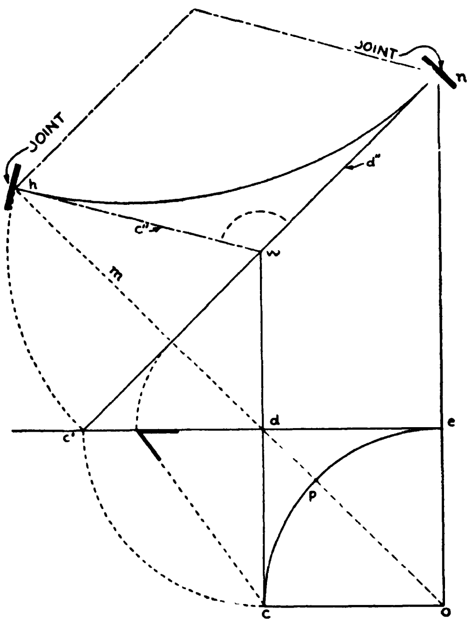


Fig. 124 Showing True View of Tangents c'' and d'' to Curve of Handrail

line *de* (Fig. 120), as an axis, until these two planes both lie in the same horizontal plane as that which contains the plan view (shown in Fig. 120 by the lines *cde* and the dotted quadrant curve tangent to these lines). The result of this revolving process is shown in Figs. 122A and 124. To lay out Fig. 124 from Fig. 123A is quite simple. The steps to be taken are as follows: with one leg of the dividers on the point *w*, Fig. 124, place the other leg on the point c' so that the distance between the two points of the dividers is equal to $c'w$ which is the true length of one of the tangents (*cd*) to the curve of the center line of the face mold of the handrail wreath. Holding the leg of the dividers stationary on point *w*, describe the arc *c'h*, every point of which will be at a distance equal to *c'w* (true length of the tangent) from point *w*. Now from point *d* draw line *m* at right angles to the tangent line *wn* or *d''* and extend it until it intersects the arc *c'h* which was drawn. Now a straight line, *c''*, drawn from this point of intersection, *h*, to point *w* will represent the true length of the tangent indicated in the plan view as *cd* and will also represent the true angle which this tangent makes with the other tangent shown in the plan view as *de* (and in its true length and direction as the line *wn* or *d''*).

The object of getting these two tangents drawn out in their true length and showing the true angle between them is to enable us by means of the tangents to draw a true view of the face mold of the handrail wreath corresponding to the plan view shown in Fig. 119. This is begun by finding a method for drawing out the true curve of the center line of the face mold. In every case you have the plan view of the handrail curve to start with, as shown at *ce* in Fig. 124. Also, you know that all lines in the plan view parallel to tangent *cd* are reflected by lines in the true view of the plane parallel to the true view of the tangent, *c''* or *wh*, and all lines in the plan view parallel to the tangent line *de* are reflected by lines in the true view of the plane parallel to the true view of the tangent, *d''* or *wn*. Therefore, if five points are taken on the plan view of the curve as shown at *1, 2, 3, 4, 5* in Fig. 125 and from each one of these points lines are drawn parallel to the plan view of each of the two tangents *cd* and *de*, this gives us 5 points, 1, 2, 3, 4 and 5, on the plan view of each of the two tangents. These 5 points can be transferred as shown by the lines in Fig. 125 to the true views of the tangents. Then lines drawn from these points on the true views of the tangents *c''* and *d''* parallel to these true tangents will locate, at their intersections, 5 corresponding points which must be on the true view of the curve of the center line of the face mold. By drawing a curved line through the 5 points of intersection, the true view of the curve of the center line of the face mold of the wreath is found, which is a view looking squarely at the top or bottom surface of the curved handrail.

Knowing the width of the top surface of the handrail (which varies according to the design), the face mold of the wreath can be drawn as shown in Fig. 125. It can be drawn out to full size on heavy brown paper and then cut out and used as a pattern to cut the rough handrail wreath from a piece of plank as shown in Fig. 117. This, of course, is only the rough handrail wreath of square or rectangular cross section and from it has to be fashioned the finished wreath which, although of the same general length and curvature, is of a molded cross section such as is shown in Fig. 101 and is

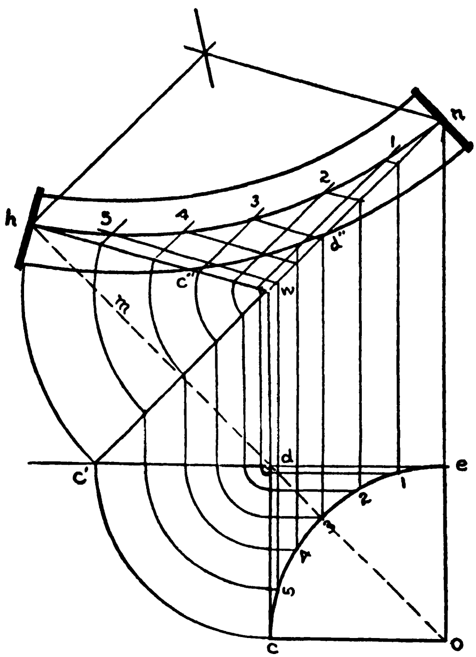


Fig. 125. How to Lay out True View of Curve of Center Line of Wreath and Face Mold from Plan View

twisted and beveled so as to present always the same molded top surface to the hand as it winds its way up at the side of the staircase. The method of fashioning the finished handrail wreath from the rough block will be described later.

Next comes the problem of finding the general curvature and the length of the face mold which is used in cutting out the rough block. So far two cases have been dealt with; namely, the wreath at the foot of a stair, which starts at a level landing and winds around a stair well through a one-quarter turn with the upper end left sloping upward (see Figs. 113, 114, 115, 116) and the wreath which starts on a slope, winds upward around a stair well through a one-quarter turn

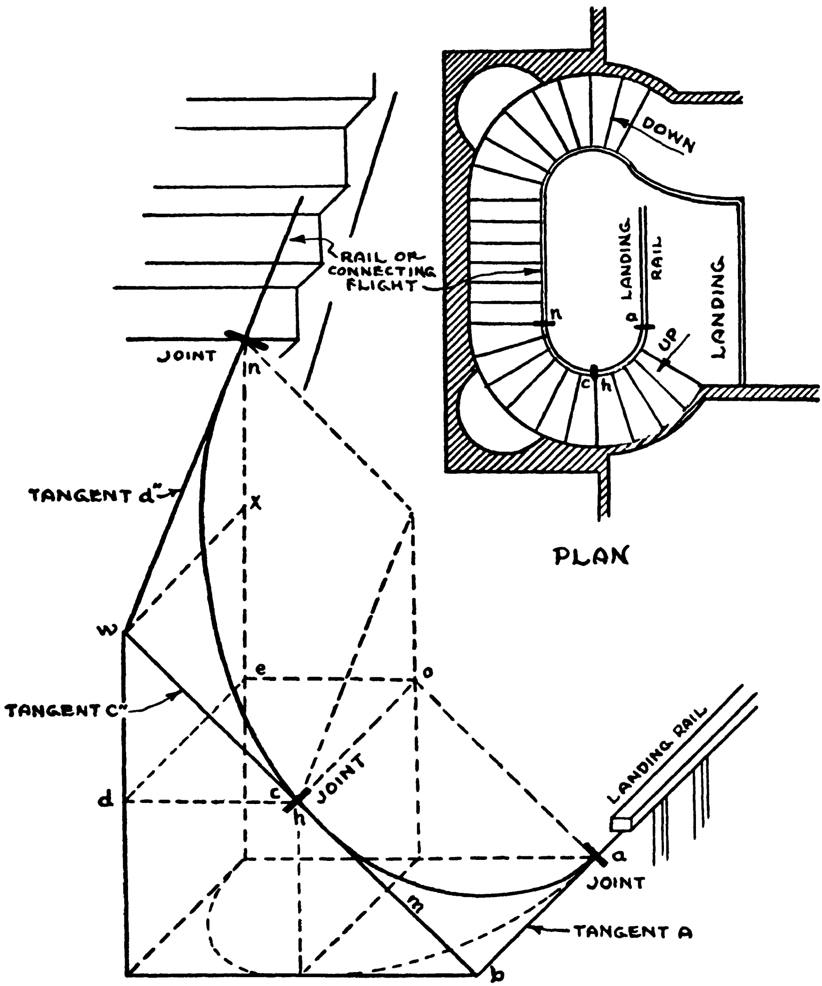


Fig. 126. Plan and Isometric View of Handrail Making a Half Turn

and finishes with the upper end also on a slope. (See Figs. 119, 120, 121, 124 and 125.)

Fig. 126 shows in plan and in isometric view these two cases combined to form a continuous curved handrail, starting at a level landing and winding around a stair well through a one-half turn with the upper end left sloping upward. Fig. 126 is an isometric view of the curved center lines of the face molds for the combined wreaths and the tangents to the curves of these center lines. It will be observed that this figure is made up of Figs. 113 and 120 combined. The lower part, which is like Fig. 113, is here shown to connect with a level landing rail at *a*. The joint having been made square to the level tangent, *a* will butt square to a square end of the level rail shown in the rough rectangular shape in the lower right-hand corner of Fig. 126. The joint at the upper end of the lower part (at *h* in Fig. 113) is shown to connect the two wreaths and is made square to the inclined tangent *m* of the lower wreath, and also square to the inclined tangent c'' of the upper wreath; the two tangents, aligning, guarantee a square butt joint. The upper joint is made square to the tangent d'', which is here shown to align with the rail of the connecting flight; the joint will consequently butt square to the end of the rail of the flight above.

The view given in this diagram is that of a wreath starting from a level landing, and winding around a wellhole, connecting the landing with a flight of stairs leading to a second story. It is presented to make clear the use made of tangents to square the joints in wreath construction. The wreath is shown to be in two sections, one extending from the level landing rail at *a* to a joint in the center of the wellhole at *h*, this section having one level tangent *a* and one inclined tangent *m*; the other section is shown to extend from *h* to *n*, where it is butt-jointed to the rail of the flight above.

This figure clearly shows that the joint at *a* of the bottom wreath—owing to the tangent *a* being level and therefore aligning with the level rail of the landing—will be a true butt joint; and that the joint at *h*, which connects the two wreaths, will also be a true butt joint, because it is made square to the tangent *m* of the bottom wreath and to the tangent c'' of the upper wreath, both tangents having the same inclination; also the joint at *n* will butt square to the rail of the flight above, because it is made square to the tangent d'', which is shown to have the same inclination as the rail of the flight adjoining.

As previously stated, the use made of tangents is to square the joints of the wreaths, and in this diagram it is clearly shown that the way they can be made of use is by giving each tangent its true direction. How to find the true direction, or the angle between the tangents *a* and *m* shown in Fig. 126 was demonstrated in Fig. 116 and how to find the direction of the tangents *c''* and *d''* was shown in Fig. 124.

Fig. 127 is presented to help further toward an understanding of the tangents. A study of the small scale plan in the upper left-

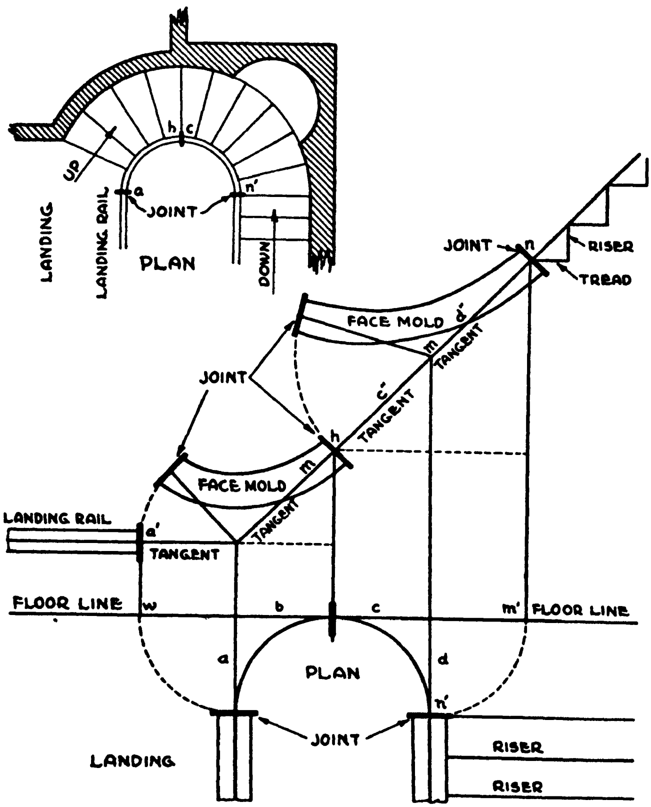


Fig. 127. Tangents Unfolded to Find Their Inclination

hand corner will reveal that it is the same as the lower half of the plan shown in Fig. 126 but turned around. Therefore, Fig. 127 is a diagrammatic view of the handrail of the same stair shown in Fig. 126, but looking at it from the opposite side, that is, from the well-hole side instead of from the outside. In the diagram of Fig. 127 the tangents are unfolded; that is, they are stretched out for the purpose of finding the inclination of each one over and above the plan tangents. The side plan tangent *a* is shown stretched out to the floor line, and its elevation a' is a level line. The side plan tangent d is also stretched out to the floor line, as shown by the arc $n'm'$. By this process the plan tangents are now in one straight line on the floor line, as shown from w to m'. Upon each one, erect a perpendicular line as shown, and from m' measure to n, the height the wreath is to ascend around the wellhole. In practice, the number of risers in the wellhole determines this height, which equals riser height times number of risers, plus height of landing rail above floor line.

Now, from point n, draw a few treads and risers as shown; and along the nosing of the steps, draw the pitch-line; continue this line over the tangents d'', c'', and m, down to where it connects with the bottom level tangent, as shown. This gives the pitch or inclination to the tangents over and above the wellhole. The same line is shown in Fig. 126, folded around the wellhole, from n, where it connects with the flight at the upper end of the wellhole, to a, where it connects with the level landing rail at the bottom of the wellhole. It will be observed that the upper portion, from joint n to joint h, over the tangents c'' and d'', coincides with the pitch-line of the same tangents as presented in Fig. 120, where they are used to find the true angle between the tangents as it is required on the face-mold to square the joints of the wreath at h.

In Fig. 126 the same pitch is shown given to tangent m as in Fig. 127; and in both figures the pitch is shown to be the same as that over and above the upper connecting tangents c'' and d'', which is a necessary condition where a joint, as shown at h in Figs. 126 and 127, is to connect two pieces of wreath.

In Fig. 127 are shown the two face molds for the wreaths, placed upon the pitch-line of the tangents over the wellhole. The angles between the tangents of the face molds have been found in this figure by the same method as in Figs. 116 and 124, which, if compared with the present figure, will be found to correspond, excepting only the curves of the face molds in Fig. 127.

The foregoing explanation of the tangents will give a fairly good idea of the use made of tangents in wreath construction. The treatment, however, would not be complete if left off at this point, as it shows how to handle tangents under only two conditions—namely, first, when one tangent inclines and the other is level, as at a' and m; second, when both tangents incline, as shown at c'' and d''.

In Fig. 128 is shown a wellhole connecting two flights, where two portions of unequal pitch occur in both pieces of wreath. The first piece over the tangents *a* and *b* is shown to extend from the square end of the straight rail of the bottom flight, to the joint in the center of the wellhole, the bottom tangent *a″* in this wreath inclining more than the upper tangent *b″*. The other piece of wreath is shown to

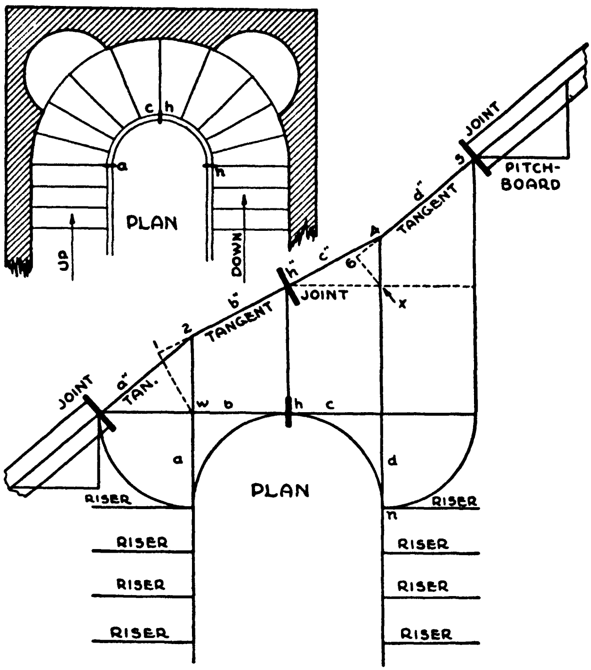


Fig. 128. Wellhole with Two Wreath Pieces Each Containing Portions of Unequal Pitch

connect with the bottom one at the joint *h″* in the center of the wellhole, and to extend over tangents *c″* and *d″* to connect with the rail of the upper flight. The relative inclination of the two tangents in this wreath is the reverse of that of the two tangents of the lower wreath. In the lower piece, the bottom tangent *a″*, as previously stated, inclines considerably more than does the upper tangent *b″*; while in the upper piece, the bottom tangent *c″* inclines considerably less than the upper tangent *d″*.

The question may arise: What causes this? Is it for variation in the inclination of the tangents over the wellhole? It is simply owing to the tangents being used in handrailing to square the joints.

The inclination of the bottom tangent *a″* of the bottom wreath is clearly shown in the diagram to be determined by the inclination of the bottom flight. The joint at *a″* is made square to both the straight rail of the flight and to the bottom tangent of the wreath; the rail and tangent, therefore, must be equally inclined, otherwise the joint will not be a true butt joint. The same remarks apply to the joint at *5*, where the upper wreath is shown jointed to the straight rail of the upper flight. In this case, tangent *d″* must be fixed to incline conformably to the inclination of the upper rail; otherwise the joint at *5* will not be a true butt joint.

Fig. 127 shows the curved handrail at the lower part of the stair from the level landing at the lower floor up around the semicircular wellhole to connect with the handrail of the straight part of the staircase. Continuing on up this staircase (Fig. 126), you see the upper part which winds around another semicircular wellhole from the straight part of the staircase up to the level landing above, where the curved and sloping handrail connects with the level rail at the edge of the landing guarding the wellhole. See Fig. 107. Fig. 129 is a diagram of the tangents and face molds for the wreaths for this upper part of the handrail.

Tangents in this example will be two unequally inclined tangents for the bottom wreath; and for the top wreath, one inclined and one level tangent, the topmost or level tangent being in line with the landing rail. The face molds are shown drawn out to scale, the sloping planes in which they lie having been revolved about the lines *b″* and *c″*, so that the handrail wreaths appear to lie on their backs, as it were, with reference to their natural position; however, this position allows them to be shown in their true length and curvature (to scale).

The face molds as shown in this figure will further help towards an understanding of the method of laying out face molds. It will be seen that the pitch or slope of the bottom rail (the straight part of the handrail from which the curved wreath starts), is determined by the relation of the width of the stair tread to the height of the stair riser. This pitch, or slope, in turn fixes the pitch of the tangent from *a″* to *b″*, a condition caused by the necessity of jointing the curved wreath to the end of the straight sloping handrail at *a″*, this joint being made square to both the straight sloping rail and the bottom tangent a''. The horizontal line drawn through points a'', w, b and c is supposed to represent a horizontal plane just the height of the top of the handrail above the horizontal plane of the last straight tread of the straight part of the stair before it begins to curve around the semicircular wellhole.

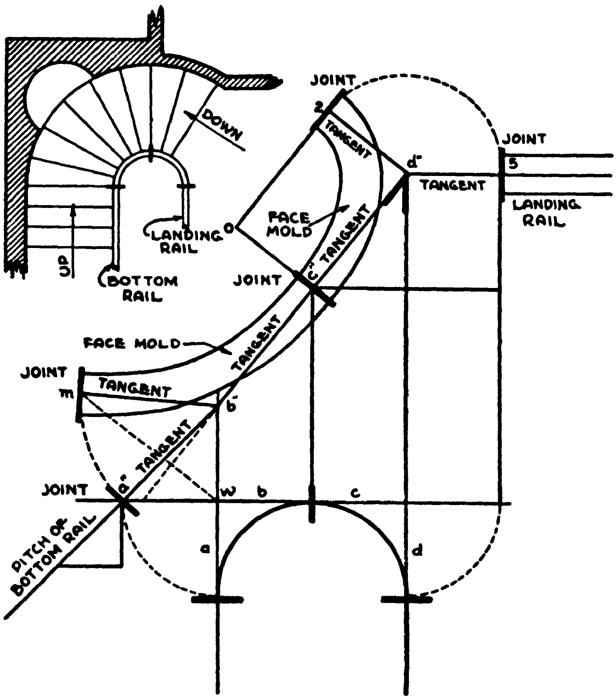


Fig. 129. Plan at Upper Landing and Diagram of Tangents and Face Mold

As the handrail curves upward around the wellhole it rises above this horizontal plane and at last connects to the level handrail at the upper landing, which is in a horizontal plane just the height of the top of the handrail above the level upper landing. As the curving handrail ascends, it rises through a distance just equal to the combined height of all the risers crossed in plan by the plan view of the tangents to the handrail.

In Fig. 129, tangents b and c, shown in elevation as tangent b'' and c'', slope upward to point d''. To find point d'', draw a vertical line at right angles to the base line $a''wbc$ at the end of the plan view of tangent *c*, and locate point *d″* on this vertical line at a distance above the horizontal line *a″wbc* just equal (to scale) to the combined height of all the risers crossed by the 3 tangents *a*, *b*, and *c*. This locates point *d″* and the sloping line *b″c″d″* can be drawn representing the elevation view of the two tangents *b″* and *c″*. Tangent *d″* is level in this case as it does not cross any risers in the plan view, since it is located above the level upper landing. It is represented in elevation view by the line *d″ 5* in Fig. 129.

The elevation view of the tangents *a″*, *b″* and *c″* and *d″* shows (to scale) the true length of each of these tangents and can be used to find the true size and curvature of the face molds, but they are not here shown in their true relation to each other. In Fig. 129 the tangents of the face mold for the bottom wreath are shown to be *a″* and *b″*, but *a″* must be placed in its true position.

To place tangent *a″* in its true position with respect to tangent *b″*, so that the face mold can be drawn, it is revolved about the end *b″*, as shown by the arc to *m*, cutting a line previously drawn from *w* square to tangent *b″*, extended. By connecting point *m* to point *b″* the bottom tangent is placed in its correct position with respect to tangent *b″*, and a true view of the two tangents is obtained. From these tangents the face mold can be drawn, as shown, after its center line has been drawn out as a curved line from *m* to *c″*. The curved center line is not shown in the figure. The joints are shown square to the tangents at points *m* and *c″*.

The upper piece of wreath in this example is shown to have tangent *c″* sloping. The inclination or slope of it is the same as the slope of the upper tangent *b″* of the bottom wreath, so that the joint at *c″*, when made square to both tangents *b″* and *c″* will butt square when put together.

The tangent *d″* is shown to be level, so that the joint at point *5*, when squared with it, will butt square with the square end of the level landing rail. These tangents *c″* and *d″5*, however, are not shown in their true relation to each other, although they are shown in their true length. In order to set them in their true relation to each other, the level tangent *d″5* is shown revolved to a position at right angles to the tangent *c″*. This puts it in its true position relative to tangent *c″* because it is really horizontal, while tangent *c″* lies in a vertical plane, and any horizontal line is at right angles to every line which lies in a vertical plane. Point *5* is revolved around *d″* as a center to point *2* on the line at right angles to *c″d″* at *d″*. It will be observed that the line *d″2*, then, is in its true position at right angles to tangent *c″*, and the face mold can be drawn.

A knowledge of the principle involved in the preceding explanation will enable the reader to draw the face mold for any wreath of this kind where the lower tangent is sloping and the upper tangent is level, by merely drawing two lines at right angles to each other as shown in Fig. 130, in which *d″5* and *d″c″* are equal respectively to the true lengths of the level tangent *d″5* and the inclined tangent

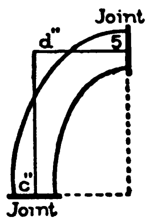


Fig. 130. Drawing Face Mold when One Tangent Is Level and One Inclined over Right-Angled Plan

c″ in Fig. 129. The joint at point *5* is to be made square to *d″5* and the joint at point *c″* is to be made square to *d″c″*. Comparing this figure with the face mold as shown for the upper wreath in Fig. 129, it will be seen that the two are alike but reversed.

The case of a handrail wreath has been considered, starting from the level position and winding upward around a semicircular wellhole to connect with a sloping straight handrail; and the case of a wreath starting with a connection to a sloping straight handrail and winding upward around a semicircular wellhole to connect at the top to a level handrail at the landing above.

Another case sometimes encountered is the handrail wreath which starts with a connection to a sloping straight handrail and winds upward around a semicircular wellhole, to connect with a sloping, straight handrail above, that is, where two straight flights of stairs leading in opposite directions are connected by a circular stair winding about a semicircular wellhole. Fig. 128 shows such a case in which the two tangents to each quadrant of the semicircular handrail in plan slope upward at different pitches, or slopes, due to the fact that tangents *a* and *d* have their slopes fixed by the provision that they must fit square to the straight sloping handrails of the straight flights of stairs (below in the case of tangent *a*, and above in the other case of tangent *d*) while the slopes of tangents *b* and *c* are fixed by the combined height of the risers which are crossed by them in plan and by the fact that they must fit square to each other where they meet at the point *h*.

The tangents to the first piece of handrail wreath are shown in elevation by the lines a'' and b'' which are actually located over the plan view of the tangents *a* and *b*. The corresponding wreath extends from the square end of the straight, sloping rail of the bottom flight to the joint *h*, at the end of the wellhole. The bottom tangent a'' has a steeper slope than the upper tangent b''. The tangents to the other piece of handrail wreath are shown in elevation by the lines c'' and d'', which are actually located over the plan view of the tangents *c* and *d*. The corresponding wreath extends from the joint *h* at the end of the semicircular wellhole up to the straight rail of the upper flight of the stairs at *n*. The bottom tangent c'' in this case has a flatter slope than the upper tangent d''. The inclination of the bottom tangent a'', of the bottom wreath, is clearly shown in the diagram to be determined by the pitch or slope of the bottom straight flight of stairs. The joint a'' is made square to both the straight rail of the bottom straight flight and to the bottom tangent a'' of the curved handrail wreath. The rail and tangent, therefore, must have the same slope, otherwise the joint will not be a true butt joint. The same remarks apply to the joint at the point *5*, where the upper wreath d'' is shown jointed to the straight rail of the upper flight. In this case, tangent d'' must be sloped so as to conform to the slope of the upper straight rail, otherwise the joint at point *5* will not be a true butt joint. The slopes of the tangents b'' and c'' are determined by the run of these tangents in plan; that is, the length of tangents *b* and *c*, and the combined height of any risers crossed by these tangents in the plan view.

The two tangents c'' and b'' must have the same slope in order that the joint at h'' may be a true butt joint. In this figure the tangents a'', b'', c'' and d'' are shown in elevation and in their true length, but not in their true relation to each other. If the diagram of this figure (Fig. 128) were to be folded on the line *wbhc*, up from the plane of the page, and were also to be folded on the lines *w2* and *nd4* (similar to the way in which the diagram of Fig. 127 is shown to be folded in Fig. 126) the tangents of the elevation a'', b'' c'' and d'' would stand over and above the plan tangents *a*, *b*, *c*, and *d*. In practical work this diagram must be drawn out to full size. It gives the true length (to scale) of each tangent as required for laying out the face molds, but must be changed in order to show them in their true relation to each other.

In order to lay them out in their true relation to each other,

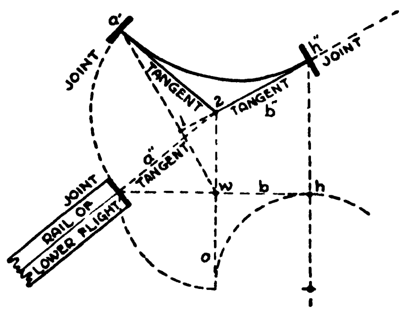


Fig. 131. Finding True Angle between Tangents for Bottom Wreath of Fig. 128

extend tangent b'' to the left, or downward, from point *2* in the direction of point *1* and draw a line from point *w*, at right angles to line $h''2$-*1*, extending this line, *w1*, well beyond the point *1*. Take the dividers and with one point of the dividers fixed at point *2*, measure off with the other point of the dividers the length of the tangent a'' and swing the dividers around point *2* until the other point of the dividers coincides with the line *w1* (extended) at a' Fig. 131. The line joining point a' with the point *2* gives the true angle between tangent b'' and tangent a'' and shows the correct position of tangent a'' for laying out the face mold for the lower part of the wreath. Fig. 131 shows this layout of the tangents.

In much the same way tangent d'' (Fig. 128) must be extended from point *4* to the left, or downward, in the direction of the point *6*, and a line must be drawn from point *x* at right angles to tangent $d''4$-*6* and extended beyond point *6*, see Fig. 132. With a point of the dividers fixed at point *4* and the dividers adjusted to measure the distance from *4* to *h''* (which is the true length of tangent *c''*), swing the dividers around point *4* until the other point of the dividers coincides with the line *x6* (extended) as shown in Fig. 132 at *h''*, and draw a line from this point to point *4*. The line thus drawn will give the true angle between the tangents *d''* and *c''* and will show the correct position of tangent *c''* with relation to tangent *d''* for

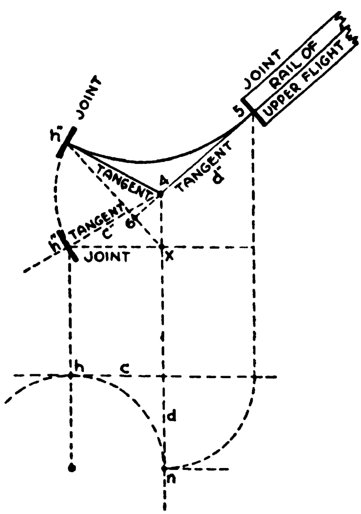


Fig. 132. Finding True Angle between Tangents for Upper Wreath of Fig. 128

laying out the face mold for the upper part of the handrail wreath. Fig. 132 shows this layout of the tangents.

Two cases often met in connection with the newel post usually found at the foot of a staircase have not as yet been considered. It is generally felt that the appearance of the stair is improved by widening it at the start, which makes it necessary to have the first three or four treads longer than the ones above, and to have the handrail curved and at the same time flattened out or *ramped* so as to be level at the point where it meets the newel post. A plan view of the start of such a stair is shown in Fig. 133 and another design not quite so much flared is shown in Fig. 134. In Fig. 133 the flare of the stairs and the consequent curvature of the handrail are so great that the angle between the two tangents to the curve of the handrail in the plan view is an acute angle. In all the preceding examples, the tangents to the handrail wreaths in the plan view were at right angles to each other. Fig. 133 shows the plan of the curved steps at the bottom of the stairway which has also a curved

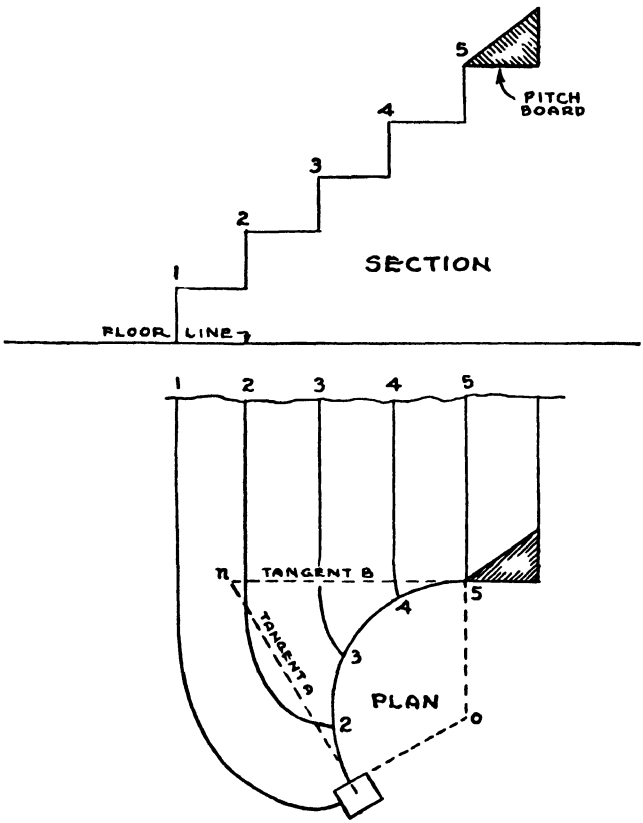


Fig. 133 Section and Plan View of Curved Steps at the Bottom of a Stairway

stringer struck from a center at *o*. The curve of the handrail of course follows the stringer and has its center also at the point *o* in the plan view. The plan tangents to the handrail curve are shown as *A* and *B* and, as will be seen, they form an acute angle with each other. Where it meets the newel post, the handrail is ramped so that it will be level at this point, and that means that the bottom tangent *A* must be level, since it is tangent to the level end of the ramped handrail. The other tangent, *B*, as will be seen in the plan view, crosses four of the stair risers in plan and must be sloping.

In Fig. 135 is shown how to find the true angle between the two tangents and how to lay out the face mold, or pattern, by means of which the rough block for the handrail wreath can be cut from a piece of thick plank. This diagram must be drawn out full size, but it is not too large to be drawn out on a large drawing board. The

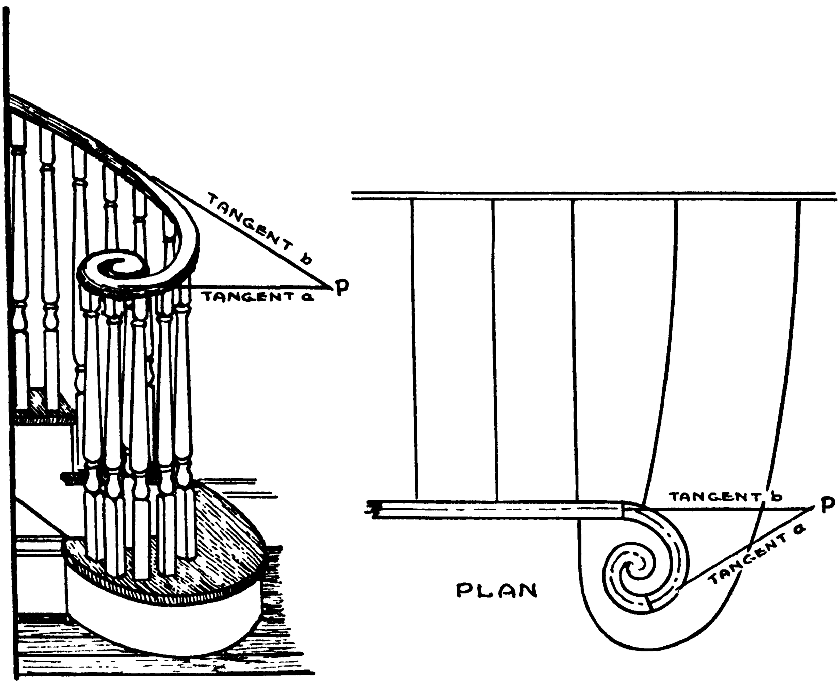


Fig. 134. Elevation and Plan of a Portion of Staircase Showing Curved Bottom Step

lower part of the figure shows a plan view of the curve of the center line of the top of the handrail (marked "plan"). It shows the plan view of the top of the newel post and the two tangents to the curve of the center line of the handrail marked "Tangent *a*" and "Tangent *b*". This figure also shows the center, *o*, from which the plan view curve of the handrail is drawn, and the lines joining this point, *o*, with the end of the plan view of tangent *a*, and with the end of the plan view of tangent *b*. These two lines are not at right angles to each other as are the corresponding lines in Figs. 124 and 123A;

instead, the angle between them is an obtuse angle. Now let the line of tangent *b*, extended to the left, represent the floor line and above this floor line draw an elevation view of the two tangents, *a* and *b*. Next, revolve the plane containing these tangents about the line *n5* into the plane of the paper so that you can look at these tangents in their true length and relation to each other and, by means of them, draw the true curve of the face mold.

A study of the plan in Fig. 133 shows that tangent *a* is level

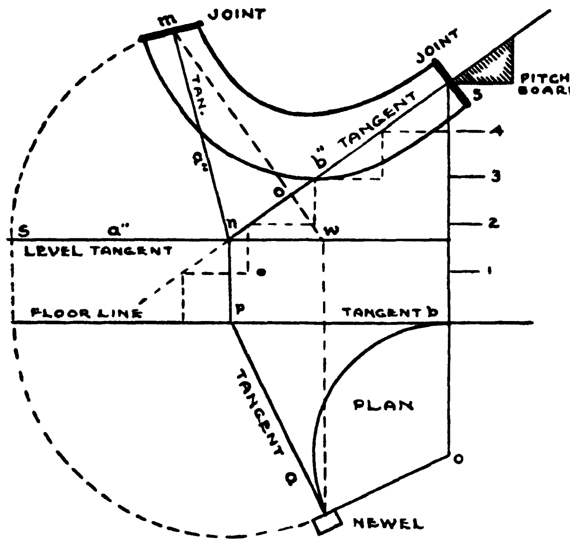


Fig. 135. Method of Finding True Angle between Tangents and Layout for Face Mold

and that the handrail curve, as well as tangent *b*, starts at the level of tangent *a*, and both slope upward at the same pitch or slope as would a huge sheet of glass or a plane resting on the nosings of the steps. Although the handrail and tangents *a* and *b* are not actually in the same plane with the nosings of the steps, but are really about 33 inches higher up, the sloping plane in which they lie is parallel to the plane of the nosings and, for the purposes of studying and laying out the curve of the handrail, imagine the handrail and tangents to be dropped vertically down until they lie in the same sloping plane as the nosings of the steps.

Now in order to lay out the sloping tangent *b* in elevation view in Fig. 135, refer to Fig. 133 and note that the upper end of tangent *b* is at point *5* on line *O5* and that point *5* is at a height equal to the combined height of the first five risers above the floor level. Therefore, in Fig. 135 draw line *O5* from point *O* at right angles to the floor line and to tangent *b* in plan. From the floor line lay off on the line *O5* the height of five risers *1, 2, 3, 4, 5*. These heights are laid off to scale in the figure, but in a full sized layout they would be set out to full height of the risers (about 7 inches each.) This gives us point *5*. Now just to the right of point *5* in Fig. 135, lay out the pitch-board for the stair; that is, a figure with horizontal line equal to the width of the tread (about 11 inches) and vertical line equal to the height of the riser (about 7 inches). This will give us the slope of the line to draw through point *5*, representing the slope of the plane containing tangent *b* and representing in elevation the tangent *b* in its true length as tangent *b″*. Continue this sloping line down to the floor line and, from *p*, the intersection of tangents *a* and *b* on the floor line, erect a perpendicular line cutting the sloping line of tangent *b″* at *n*. This point, *n*, is then the lower end of tangent *b″* and the point in which tangent *b″* intersects the level tangent *a″*, shown in the elevation view of Fig. 135. Tangent *a″* really lies in a vertical plane directly above the plan view of tangent *a*, but this vertical plane has been revolved about the vertical line *np* into the plane of the paper to give us a true view in elevation of the level tangent *a″*. Its length to the left from point *n* is the same as the length of the plan view of tangent *a*, because this tangent is level, or horizontal.

Now from the intersection of tangent *a* with the newel post in the plan view, Fig. 135, draw the vertical dotted line at right angles to the level tangent line *nw*, intersecting this line in the point *w*. Then distance *nw* is the distorted, or foreshortened, view of tangent *a* in elevation; and *w* is the elevation view of the point in which tangent *a* and the curved ramped handrail meet the newel post.

In order to get a true view of the two tangents, *a* and *b*, and of the face mold of the handrail wreath in their true lengths and true relation to each other, imagine that the plane in which they all lie is revolved about the line of tangent *b″* into the plane of the paper. When this is done, point *w* (the point of intersection of tangent *a* and the center line of the face mold with the newel) will travel in a path at right angles to the line of tangent *b″*, as shown by the dotted line *wom*, and the point *m* must be on this line; also point *m* must be at a distance from point n equal to the true length of tangent a''. Therefore, with one point of the dividers on point n and the other point of the dividers set to lay off the length (sn) of tangent a'', the arc sm is struck intersecting line wom in the point m. Connect points m and n and this line is the true position of tangent a'' with relation to tangent b''. The angle $mn5$ is the true angle between the two tangents.

Having established the true picture of the two tangents a'' and b'' in their true relation to each other, the curved center line of the face mold can be laid out tangent to them, and, from this curved center line, the face mold itself can be laid out and the joints at the two ends of the face mold can be drawn at right angles to the tangents, which will make these joints fit squarely. These two joints

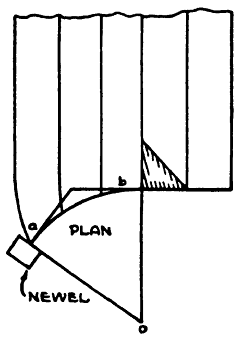


Fig. 136 Bottom Steps with Obtuse-Angle Plan

are, the joint at m with the newel post, and the one at 5 with the sloping end of the straight handrail above. As this wreath is rather long and is ramped or flattened off at the lower end, it cannot be cut from a plank but must either be cut from a much larger block of wood or be made up of several pieces.

Fig. 136 shows in plan an example of a stair where the few steps at the bottom of the flight are flared slightly and the curve of the handrail wreath is such that the tangents to it, a and b, will form in plan view an obtuse angle with each other. The curve of the center line of the handrail wreath will be less than a quadrant, whereas in the last example considered it was more than a quadrant. The curve in plan is struck from the center, o, and covers only the three lowest steps, from the newel post up to the straight sloping part of the handrail.

In Fig. 137 is shown how to develop or lay out the two tangents to the center line of the face mold of the handrail wreath and the face mold itself. This handrail is not ramped, that is, it is not flattened or leveled off at the bottom where it meets the face of the newel post, therefore the bottom tangent, *a*, is not level.

To make the layout shown in Fig. 137, start with the point *o*. Draw out the plan view of the curve of the handrail full size, striking the curve from *o* as a center. Draw the plan view of the newel post and the plan view of the two tangents *a* and *b*. Extend the line of tangent *b* to represent the floor line as shown, at right angles to the radius line from *o*, and extend this radius line up to the point marked *3*. What is marked "floor line" is really the level of the tread of the

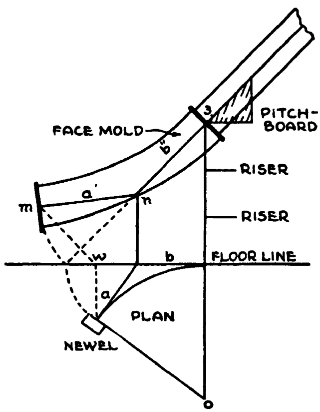


Fig. 137. Developing Face Mold, Obtuse-Angle Plan

first step, since that is where one would stand with his hand on the handrail wreath just before stepping down the last step to the floor. The point *3* therefore can be fixed at a distance equal to the height of three risers above the line marked "floor line," since the curve of the handrail and the tangents cross three risers before meeting the straight sloping part of the handrail.

At point *3* construct the pitch-board, the horizontal line equal to the tread, and the vertical line equal to the riser, and with this determining the slope, draw *b″* from point *3* to point *n*. Point *n* is fixed by drawing a vertical line at right angles to the floor line from the junction of the plan view of the two tangents *a* and *b*. With the dividers on this junction point, strike an arc from the plan view of the face of the newel post around to the floor line, and draw the dotted line from this point to point *n*, which will represent the true length of tangent *a*.

In this case the dotted line is in line with the tangent line *b″* or *n3* because the two tangents *a* and *b* are the same length in the plan view and both cross the same number of risers, which means that they have the same slope although they slope in different directions. With one point of the dividers on point *n* and with the above-mentioned dotted line as radius, strike the curve passing through point *m*. Any and every point on this curve is at a distance from point *n* equal to the true length of the tangent *a*. Now from the plan view of the intersection of tangent *a* and the handrail curve with the newel post, draw the dotted line at right angles to the floor line, meeting the floor line in the point *w*, and from point *w* draw a line *wm* at right angles to the line *n3*. The line *wm* intersects the curve at *m*, thus locating this point (which is the lower end of tangent *a″* in its true position). Draw the line *mn* to form tangent *a″* in its true length and in its true relation to tangent *b″*. Having these two tangents in their true length and relation to each other, draw tangent to them the curve of the center line of the face mold and from that curve the face mold itself can be laid out, turned upside down as though you were looking directly at the underside of the handrail. The two joints will be drawn at right angles to, or *square*, with the tangents. The joint at *m* will then connect square with the face of the newel post, and the joint at *3* will connect squarely to the straight, sloping handrail of the upper part of the flight of stairs just above the bottom three steps. See Fig. 136.

The wreath in this example follows closely the line or plane of the nosings of the steps, although it actually lies in a plane parallel to, and about 3 feet above, this plane. In other words, it is not ramped as was the handrail shown in Figs. 133, 134 and 135. In those figures the bottom tangent, *a*, was level, while in Fig. 136 the bottom tangent slopes. Therefore the method explained in connection with Fig. 133 can be applied to a case where the handrail wreath is ramped or brought out to a level position; the method explained in connection with Fig. 136 is applicable to a handrail wreath which is not ramped but which follows a plane parallel to the plane of the nosings of the steps until it reaches the newel.

CHAPTER VI

BEVELS

The curves of the center line of the face mold for almost any condition can be laid out by the methods so far explained, and from this curve the face mold can also be laid out if the width of the face mold is known. This width must be made large enough so that the mold of the handrail can be cut out from the rough block of the wreath. A method of finding what this width should be and for laying out the face mold will be explained hereinafter, but first it is necessary to consider how the molding of the handrail can be cut out

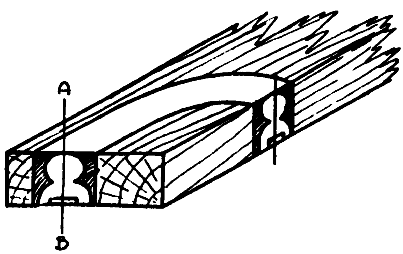


Fig. 138. Handrail Wreath to be Cut from a Thick Plank

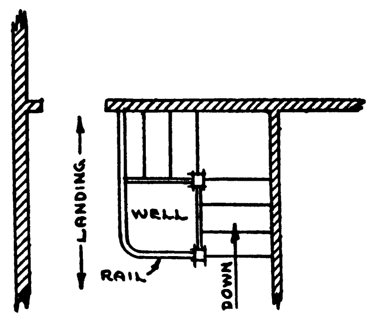


Fig. 139. Wreath in a Level Landing Rail

of the rough block. This brings us to a consideration of what are known as *bevels*.

Fig. 138 shows how the rough block for a handrail wreath can be cut out of a piece of thick plank. If the wreath is a part of a level handrail such as might be found at the second-floor landing of a stair, like that shown in plan in Fig. 139, and where the wreath in perspective view would appear as shown at *M-871* in Fig. 105, the axis of the mold *AB* (Fig. 138) is, throughout the entire length of the handrail wreath, at right angles to the planes of the top and bottom surfaces of the rough block from which the wreath is to be cut.

This is only true in the case of a *level* handrail wreath and it is so because, in this case only, the rough block as it lies on the work bench ready to be fashioned into the molded handrail wreath, has its top and bottom surfaces in the same position which they will occupy when the wreath is in its final position in the handrail, that is, in a horizontal plane. In this case only, therefore, the molded section of the handrail, such as is shown at *M-874* in Fig. 105, can be drawn out on the ends of the rough block of the wreath, as shown in Fig. 138, with its axis at right angles to the top and bottom surfaces of the rough block of the wreath, and the molded wreath can be cut out and finished with the knowledge that the mold will fit squarely with the ends of the straight parts of the handrail.

Now suppose that the handrail wreath is at the top landing of a flight of stairs leading down from a gallery where the stair starts to

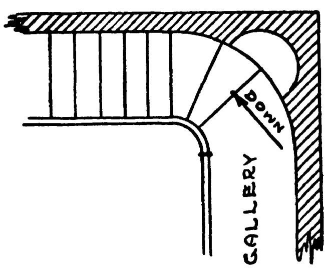


Fig. 140. Wreath Having One Tangent Level and One Sloping

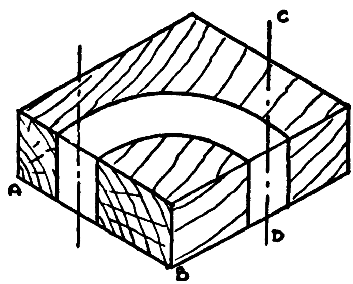


Fig. 141. Curve of a Level Wreath Marked Out on Plank

go down, and that the stair is a winding stair with no newel at the top, but with a continuous handrail as shown in plan in Fig. 140. In this case one tangent to the handrail curve is level (above the gallery floor) but the other tangent must follow the slope of the stairs downward at a slope determined by the height of the riser and width of tread of the stair. Imagine the piece of plank from which the handrail wreath is to be cut, lying flat on the bench as shown in Fig. 141, and suppose that it be raised up by revolving it about the edge *AB* until its top and bottom surfaces lie in inclined or sloping planes parallel to each other and parallel to the slope of a plane passed through the lines of the nosings of the steps of the stair being considered, as shown in Fig. 142.

Now remember that the upper end of the handrail wreath is a continuation of the level handrail at the edge of the landing and must join onto this level handrail without any apparent break; therefore the axis of the handrail molding must be vertical at the upper end of the handrail wreath to match the vertical axis of the molding of the level handrail. However, Fig. 142 shows that, in order to be vertical, this axis, *CD*, must pass diagonally through the rectangular upper end section of the rough wreath instead of at right angles to the planes of the top and bottom surfaces of the plank, and of the rough wreath, as does the axis *CD* in Fig. 141, which represents a level wreath. The angle *ECD*, which this vertical axis makes with the plane of the top surface of the rough wreath, (represented by the line of the upper joint *CE*) is called the bevel, and it is in this case equal to the angle which the risers of the steps make with the sloping plane in which lie the nosings of the treads; in other words, it is the

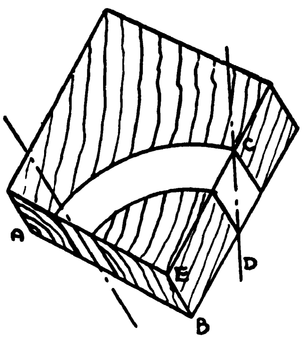


Fig. 142. Curve of Sloping Wreath Marked Out on Plank and Shown Inclined

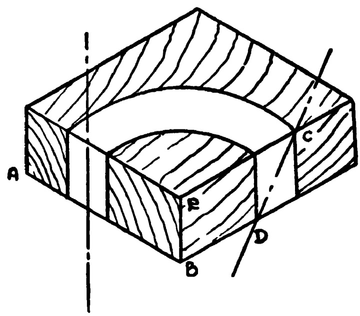


Fig. 143. Curve of Sloping Wreath Marked Out on Plank and Shown Flat

same as the angle of the pitch-board. Now, take the piece of plank shown in an inclined position in Fig. 142, with the axes of the handrail moldings, and revolve it around the edge *AB* until it again lies flat on the bench. The two axes will now appear as shown in Fig. 143, the axis *CD* of the upper end of the handrail molding being at a bevel with the top and bottom surfaces of the rough handrail wreath. This bevel, or angle, is, in this case only, the angle which the vertical planes of the risers of the steps make with the sloping plane which contains all the nosings of the steps. This is true because the upper end of the handrail wreath is in a level position when the wreath is in place and a line tangent to the lower end of the wreath is inclined in a direction parallel to the slope of the stairs. In other words, you may say that the sloping plane on which the handrail may be said to rest is inclined only in one direction with respect to a horizontal plane such as the floor of the landing or the treads of the steps.

A further result of this condition is that the axis of the handrail molding (at the *lower* end of the wreath where it joins onto the straight sloping handrail) is at right angles to the planes of the top and bottom surfaces of the rough handrail wreath and to the piece of plank from which it will be cut. This is only true of wreaths which have one end level. Other wreaths will have the axis of the handrail molding at *both* ends of the wreath at a bevel with the top and bottom surfaces of the rough handrail wreath.

A little study of Fig. 143 will show that when the molded handrail wreath is carved out of the rough wreath it will be *twisted* so as to fit properly when set up in its final sloping position. The wreath is said

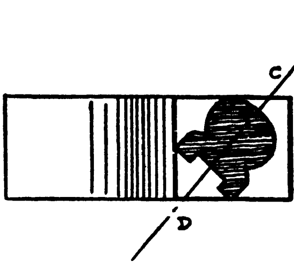


Fig. 144. Outline of Cross Section of Sloping Handrail Shown at Correct Angle with Top and Bottom Surfaces of the Rough Wreath

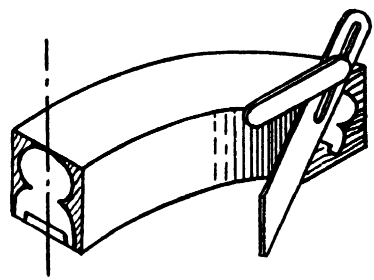


Fig. 145. Use of a Bevel to Mark Out the Proper Angle for Handrail Cross Section

to be twisted because the effect of the finished wreath is the same as if it were cut out of the rough wreath with the axes of the molded section at both ends square to the top and bottom surfaces and as if it were then grasped at both ends while in a soft pliable condition and twisted. The reason for this "twisting" is that no matter how the handrail winds about, the axis must always remain in a vertical plane so that the top surface will be properly shaped to fit the hand.

In order to be able to fashion the molded and twisted handrail wreath, it is necessary to be able to mark out, on the ends of the rough wreath, the outline of the cross section of the molded handrail, as shown in Fig. 138, with the axis (*CD* in Fig. 144) at the correct angle or bevel with relation to the top and bottom surfaces of the rough wreath, as shown in Fig. 144. A bevel is made use of for this purpose and Fig. 145 shows how the tool is used. In the case of a handrail wreath, it is set to the required angle or bevel and the handle, or thicker part, is held against the top or bottom surface of the rough wreath with the blade, or thinner part, lying across the end of the wreath. Then mark along the blade and you will have the line of the axis of the handrail molding at the proper bevel with the top or bottom surface of the rough wreath.

In the case just considered, where the sloping plane in which the handrail wreath lies is inclined in one direction only, and one of the tangents to the curve of the center line of the face mold is horizontal or level, the bevel required is the angle between the line of the riser of any one of the steps and a line drawn from nosings of two adjacent steps as shown in Fig. 146. This can be obtained by applying the bevel to a drawing or a full size layout of the staircase, or to a pitch-board for the stair, clamping the blade of the bevel and then

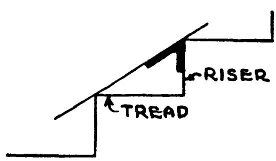


Fig. 146 Obtaining the Correct Bevel for a Wreath which Inclines in One Direction Only

applying the bevel to the upper end of the rough handrail wreath as shown in Fig. 145.

Now suppose a handrail for a winding stair such as is shown in Fig. 128, where the stair winds about the semicircular end of a wellhole and the handrail is continuous around the wellhole. In this case the handrail encircling the wellhole will be in two sections or wreaths, *ah* and *hn*, each of which will have both ends sloping to join up with the other parts of the continuously sloping handrail. In the case of any one of the two wreaths, such as *hn* for example, the two tangents to the curve of the handrail, such as *c* and *d*, both slope upward with respect to a level, horizontal plane such as the floor; *c* in one direction and *d* in another direction. In other words, the top or bottom surface of the handrail wreath rests in a plane which slopes in *two* directions with respect to a horizontal plane as it winds its way up around the curve of the stair.

In order to make clear what is meant by a "plane inclined in two directions," imagine a piece of plank (from which is to be cut the molded handrail wreath) to be lying flat on the work bench with the face mold applied to it and the rough wreath marked out on it ready to be cut out as shown in Fig. 147. In this position the top and bottom surfaces of the rough handrail wreath lie in the top and bottom surfaces of the piece of plank, which are of course in horizontal planes while the piece of plank is lying on the bench. This is not the position

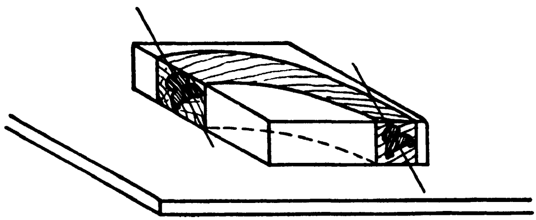


Fig. 147. Plank on which Face Mold Is Marked Out, Lying Flat

which the handrail wreath will occupy when it is in place as a part of the sloping, winding handrail. Let us try to move the piece of plank about so that the rough wreath will be in the same relative position with respect to a horizontal plane (such as the bench top or the floor) as it would occupy in its final position in the handrail.

In order to do this, raise the piece of plank up as shown in Fig. 148, keeping only one edge flat on the bench. The top and bottom surfaces slope in one direction only. Now, keeping only the right-hand corner on the bench, raise the piece of plank up into the position shown in Fig. 149. The top and bottom surfaces of the piece of plank, and consequently the top and bottom surfaces of the rough handrail wreath, now lie in a plane which slopes in two directions, and the wreath occupies a position similar to that which it will occupy when in its final position as a part of the winding handrail. The rule is

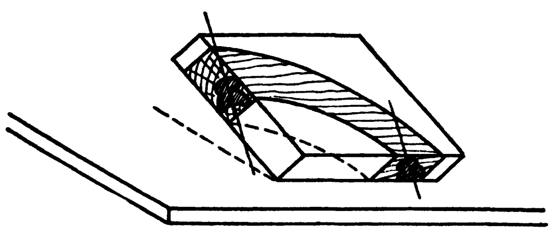


Fig. 148. Plank of Fig. 147 Inclined in One Direction Only

that the mold must be in such a position at each cross section that its axis will be in a vertical plane when the handrail is in its final position. Therefore, if the outline of the handrail molding is located on the end of the rough wreath so that its axis is in the vertical plane when the rough wreath is in the position shown in Fig. 155, it will be correct. The axis of the handrail mold is shown on each end, and it will be seen that in this case (where the plane slopes in two directions) the axis of the handrail molding is *not* at right angles to the line of the top or bottom surface of the rough wreath.

The proper angle or bevel can be found by various methods

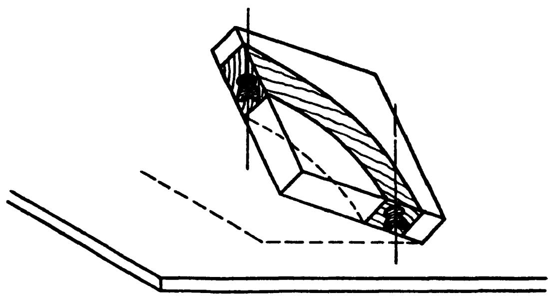


Fig. 149. Plank of Fig 147 Inclined in Two Directions, its True Position

which will be explained later. When the angle is found, the outline of the handrail molding can be drawn out on the ends of the rough handrail wreath by setting the bevel to agree with it and then applying the bevel to the end of the rough wreath, with the *handle* of the bevel (the thicker, heavier part) against the top surface of the rough handrail wreath, and the thinner *blade* of the bevel across the end surface of the rough wreath. Then the axis of the molding can be marked off along the blade of the bevel on the end surface of the wreath, Fig. 145.

Now let the piece of plank down again from its third position to the second and from the second position to the first, until it again lies flat on the bench, and you will see why the outline of the handrail molding on the end of the rough wreath must be skewed with relation to the top and bottom surfaces of the plank, and why its axis must be at a bevel with these surfaces. This is in order that the axis at every point in the wreath will lie in a vertical plane when the wreath is in its final sloping position as part of the handrail.

Methods for finding the bevels for *all wreaths* will now be explained, starting with an explanation of the use of the *trammel.*

Trammel. In the preceding pages references have been made to the use of dividers for drawing arcs of circles. In some cases, especially where diagrams are to be laid out to full size, it may be found that the radius of the arc is too great for the spread of the dividers. In such a case an instrument called a *trammel* or *beam compasses* may be used. Fig. 150 shows a set of *trammel points* and illustrates how they are used.

A smooth straight stick of hard wood is prepared and the trammel points are slipped over it, after their clamps have been loosened

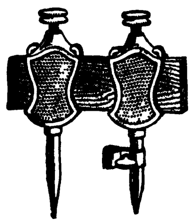


Fig. 150. Trammel Points
Courtesy of Stanley Rule and Level Plant, New Britain, Connecticut

sufficiently to permit this. Then the two trammel points (one of which has a pencil-clamp attached to it) can be moved along the stick to indicate any desired radius and clamped securely in place. The stick or *compass-beam* can then be used like a pair of dividers to draw large arcs of circles on the floor or on a bench or large drawing board.

Finding Bevels. *First Case.* In Fig. 151 is shown a diagram which might be drawn out for the handrail wreath referred to in connection with Fig. 140 where the upper tangent to the center line of the curve of the wreath is level and the lower tangent to this curve is sloping parallel to the sloping plane in which lie the nosings of all the steps of the straight flight. In this diagram let the curved line *AC* represent a plan view of the center line of the handrail wreath, point *A* being the lower end of the wreath where it joins onto the straight sloping handrail of the straight flight, and point *C* being the upper end of the wreath where it joins onto the level handrail at the edge of the upper landing.

Line *AB* is a plan view of the sloping tangent to this curve and line *BC* is a plan view of the level tangent to the curve. If tangent line *AB* is actually sloping up from point *A*, then both points *B* and *C* must really be at a higher level than point *A*. The sloping tangent *AB* lies in a vertical plane represented in the plan view by line *AB*,

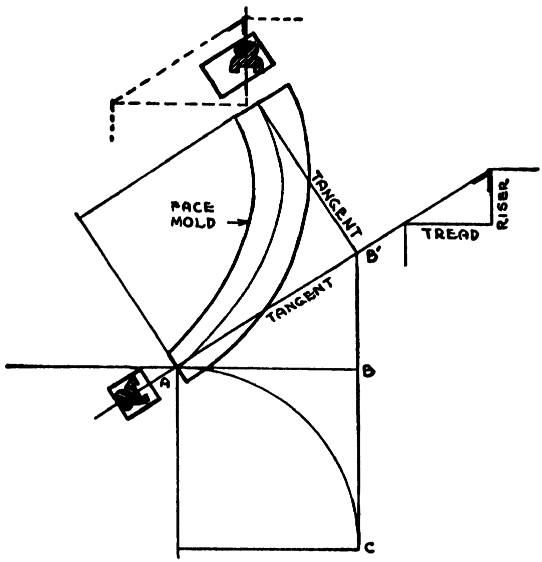


Fig. 151. Plan and Pattern of Face Mold for Curve of a Handrail Having a Sloping Lower Tangent and Level Upper Tangent

and this vertical plane can be revolved about the line *AB* as an axis until it lies flat in the plane of the page, showing the upper end of the sloping tangent at point *B′*. The line of the sloping tangent *AB′* can be laid out by making the distance *AB* equal to the width of one stair tread (11 inches), to any convenient scale, and making the distance *BB′* equal to the height of the stair riser (7 inches), to the same scale, since the slope of the tangent is the same as the slope of the stair in this case.

The bevel of the upper end of the handrail wreath *C* is the angle *AB′B*, and is the same as the upper angle of the pitch-board for this stair. At the lower end of the wreath, *A*, no bevel is required because the plane of the top or bottom surface of the rough handrail inclines in one direction only. Fig. 151 shows a face mold and bevel for a wreath with the upper tangent level and the bottom tangent sloping.

Second Case. It may be required to find the bevels for a wreath having two equally inclined tangents; that is, two tangents each sloping and both at the same angle but in different directions. An example of this is shown in Fig. 126 where both tangents *C''* and *D''* of the upper handrail wreath slope at the same angle because they both cross the same number of risers in the plan view and are of the same length in this view. Two bevels are required in this case, because the sloping planes in which the top and bottom surfaces of the rough handrail lie, are inclined, or sloped, in two directions. Because these two slopes are the same, the two bevels (one for each end of the wreath) will be the same.

An illustration in Figs. 152 and 153 also shows the twist in the

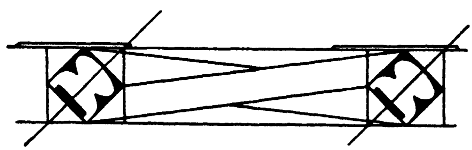


Fig. 152. Twisted Wreath, Ready to Be Molded

wreath. In this case the wreath is semicircular in plan and curves completely around the end of the wellhole.

In Fig. 154 the method for finding bevels is shown. The basic lines of this figure are the same as shown in Fig. 123A. The line marked "H. Trace" is added and it is the line in which the sloping plane containing the top or bottom surface of the rough handrail cuts a horizontal plane passed through the junction point between the straight sloping handrail next to the bottom of the curved handrail wreath and the lower end of the curved wreath itself. One end of this horizontal trace must pass through the point *C*, since this point is the lower end of the sloping wreath in plan view and is in the horizontal plane. Draw a line from *O* through *d* to *c''* square to the pitch of the tangents *c''* and *d''* and, with one point of the dividers placed at *d*, turn the arc shown tangent to *c''* over to point *h* on the line *dc*. Now connect point *h* to point *g*, as shown. The correct bevel for the lower end of the wreath is the angle *dhg*.

In Fig. 154 the quadrant curve *ce* is the plan view of the curve of the center line of the face mold of the handrail wreath. Starting at point *c* where it joins onto the straight sloping handrail, the wreath

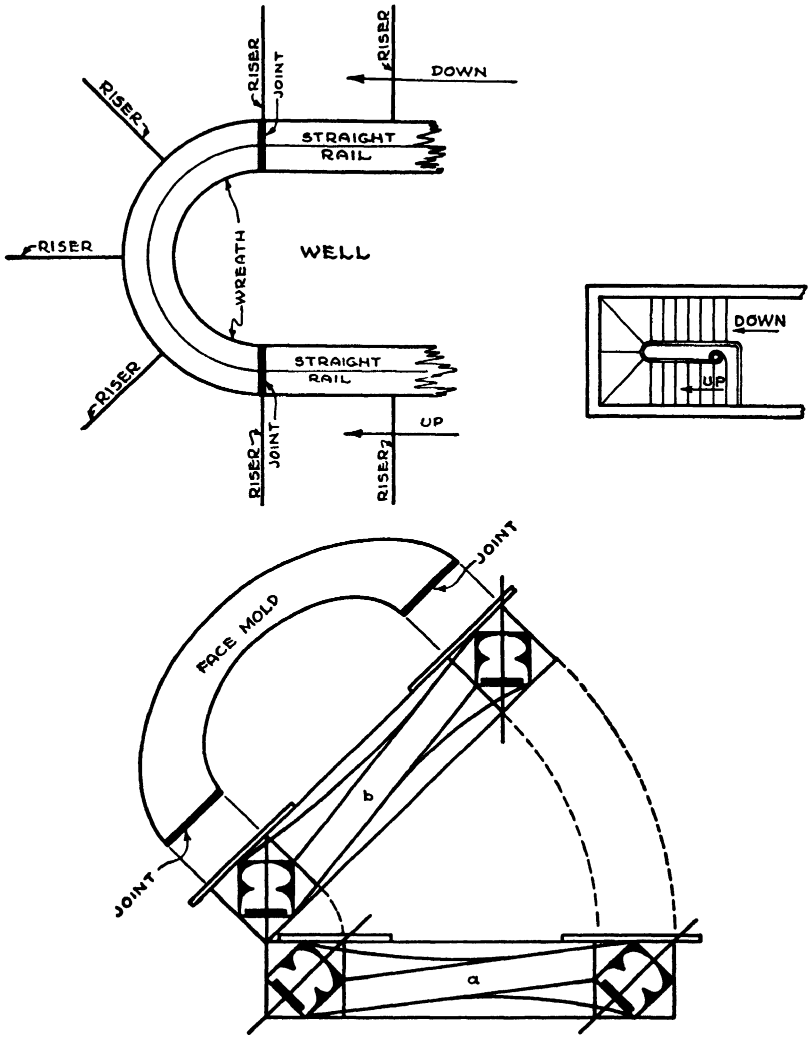


Fig. 153. Plan of Stair and Handrail Showing Twist for a Wreath Having Two Equally Inclined Tangents

slopes and curves upward as shown in Fig. 155 where the dotted curve *ce* represents the plan view of the quadrant and the inclined curve *cn* represents, in isometric or perspective view, the sloping, rising curve of the handrail wreath.

The sloping tangent *c''* as shown in Fig. 121 is actually directly above line *cd* or *hd*, while the sloping tangent *d''* as shown in Fig. 121 is actually high up above line *de*. The diagram shown in Fig. 154 is obtained by imagining line *c''* in Fig. 121 to be rotated about vertical line *wd* as an axis into the vertical plane containing sloping tangent *d''* as shown at *c'n* in Fig. 121, and then rotating the entire vertical plane represented by the triangle *c'en*, Fig. 121, about the horizontal line *c'de* down into the horizontal plane in which lies the plan view of the center line of the wreath represented by the curve *ce*. Thus the distance *ne*, Figs. 121 and 154, represents the height at which

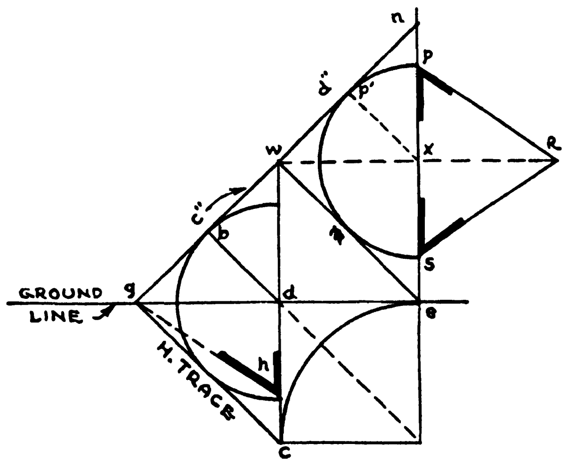


Fig. 154. Method of Finding True Angles for Bevels

the upper end of the curved handrail stands above the horizontal plane which contains the plan view of the curve *ce*.

Fig. 155 shows another isometric view similar to the view of Fig. 121 but looking from a slightly different position. In this figure, as stated, the dotted curved line *ce* represents in isometric the plan view of the center line of the curved handrail. Being the plan view, this curve *ce* must lie in a horizontal plane which is shown here as *dcoe*, and this horizontal plane is shown extended to include the triangle *gcd* so that the horizontal plane contains the trapezoid *gdeoc*. As mentioned, the upper end of the actual curve of the center line of the handrail stands some distance above this horizontal plane. The vertical line *ne* represents this distance in isometric view, *n* being the upper end of the curve and the curved line *cn* being an isometric view of the actual curve of the center line of the handrail. In this figure, as well as in Fig. 121, the sloping tangents *c''* and *d''* are shown in their true positions, and vertical planes are shown passed through these two sloping tangents. The vertical plane passed through tangent *d''* is shown by the triangle *gne* in Fig. 155, and the vertical plane passed through tangent *c''* is shown by the triangle *wdc*. Vertical plane *wdc* intersects vertical plane *gne* in the vertical

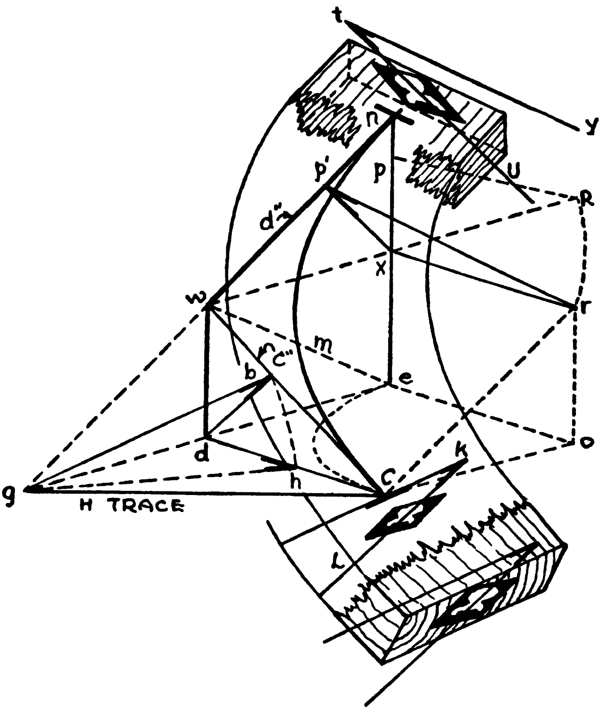


Fig. 155. Bevels Applied to Face Molds of Handrail

line *wd*, and it intersects the horizontal plane *gdeoc* in the line *dhc*. Vertical plane *gne* contains the vertical lines *ne* and *wd* and it intersects the horizontal plane *gdeoc* in the line *gde*.

The angle or bevel of the lower end of the wreath is obtained by noting that the vertical plane *wdc* passed through tangent *c''* (line *wbc*) contains the axis of the handrail molding at the lower end of the wreath at *c*. In Fig. 155 the sloping plane *cwp'r*, containing the two sloping tangents (*c''* and *d''*) and the curve of the center line of the face mold of the wreath, is shown continued down to cut the horizontal plane *gdeoc* in the line marked "H. Trace." The triangle *cgw* represents the lower part of this sloping plane. Now note that the joint line at *c,* (the lower end of the curve of the face mold) must lie in this plane because the curved face mold itself lies in this plane. This joint line *ck* is at right angles to, or square with, the tangent line *c''*, which also lies in this plane. The line of the axis of the handrail molding, *kL,* is at right angles to, or square with, the lower tangent *c''* (the line *cw*) but lies also in the vertical plane *wdc* which was passed through the tangent *c''*. The angle between the joint line, *ck* (at *c*) and the axis of the handrail molding, *kL,* is the bevel which is needed in order to lay out the axis of the handrail molding on the lower end of the rough wreath as shown by the isometric view of the end of the rough wreath.

Line *db,* drawn from point *d* at right angles to the lower tangent *c''*, is parallel to the line of the axis of the handrail mold *kL;* and line *gb,* drawn from *g* to point *b* on the lower tangent line *cw,* is at right angles to this tangent line, although this does not appear to be so because in Fig. 155 you are looking at an isometric drawing. The joint line *ck* at the lower end, *c,* of line *cw* is parallel to line *gb.*

Therefore, the angle *gbd* is the same as angle *ckL* and is the angle which is required for the bevel at the lower end of the wreath.

In order to be able to measure and use this angle and to see it in its true dimensions, imagine the triangle *gdb,* Fig. 155, to be revolved about line *gd* as an axis down into the horizontal plane as shown at *gdh.* This is done by taking point *d* as a center and swinging point *b* down into line *dc* at point *h,* and then drawing a line *gh* joining points *g* and *h.* This is shown also in Fig. 154, where the arc is swung about the center *d* and the triangle *ghd* gives the angle *ghd,* which is the required bevel.

To review this reasoning, remember that Fig. 154 shows the angles in their true dimensions (to scale) while Fig. 155 is an isometric view and therefore shows the angles distorted. Angle *ghd* in Fig. 154 is a true view of the angle shown in isometric view in Fig. 155 at *ghd.* Angle *gbd* in Fig. 155 is the same as angle *ghd* in this figure because the corresponding sides of the two triangles *gbd* and *ghd* are equal; *gh* equals *gb* and *dh* equals *db.* Angle *gbd* is the same as angle *ckL* in Fig. 155 because *ck* is parallel to *gb* and *kL* is parallel to *bd.* Therefore, because *ckL* is the isometric view of the bevel required at the lower end of the handrail wreath, then *ghd* in Fig. 154 is a true view of this bevel.

In the same way in Fig. 155, note that a line drawn at right angles from point *x* to the upper tangent *d''*, and meeting this tangent in point *p'*, is parallel to the axis *tu* of the handrail mold at the upper end of the handrail wreath at *n*. Line *xr* is drawn equal in length to *eo*, and the points *p'* and *r* are joined; then line *p'r* is parallel to the upper joint line (*ty*) at the top end of the face mold of the wreath at point *n*. Thus the angle *xp'r* is the bevel required to lay out the axis of the handrail molding on the upper end of the rough wreath, as shown by lines *ty* and *tu* and the isometric view of the upper end of the rough wreath.

Now imagine point *p'* to be swung about point *x* as a center to point *p* in the vertical line *exn* and imagine line *xr* to be swung about point *x* as a center until it is in line with line *wx* instead of at right angles to this line (in isometric). Then the angle *xpR* will lie in the same vertical plane as the upper tangent *d''* and can be measured and made use of. This is shown by the triangle *xRp* in Fig. 154, and the angle *xpR* gives the bevel for the upper end of the wreath, equal to the angle *ytu* at the top of Fig. 155. These angles do not seem to be equal in the figures because Fig. 155 is an isometric view while Fig. 154 shows the true angle.

These explanations will make it easier to understand the method of finding the bevels shown in Fig. 154. A line *bd* is drawn from point *d to c''*, square to the pitch of the tangent *c''*, and point *b* is turned over to the line *cd* at point *h*. This point *h* is then connected to point *g* as shown. The required bevel is at *h*. In order to lay out the bevel for the upper end of the handrail wreath, the line *m* is drawn having the same slope as the bottom tangent *c''*, but in another direction.

Referring again to Fig. 155, if you imagine triangle *cdw* to be swung to the *right* about the vertical line *dw* as an axis until this triangle *cdw* lies in the same vertical plane as the triangle *gdw*, and point *c* occupies the same position as does point *e* in Figs. 154 and 155 (with line *cw* in the same position as would be a line drawn from *e* to *w*) then the line *cw* would be in the same position as is the line *m*, in Fig. 154.

In Fig. 154, from the point *w*, in which the line *m*, or *ew*, cuts tangent d'', draw the horizontal line *wxR*, cutting the vertical line *exn* in the point *x*, and extending to point *R*, the distance *xR* being made equal to the distance *eo*, or the distance *cd* or *gd*. This line will correspond to the lines *wx* and *xr* in Fig. 155. The line *xR* in that figure is *xr* after being swung to the left about point *x* as a center until it lies in the same vertical plane as the triangle *wxn* and the line *wx* and, in fact, forms an extension to the line *wx*, as shown in Fig. 154.

Now in Fig. 154, place the dividers on point *x* and draw a semi-circular arc as shown, tangent to the line *m*, and tangent also to the upper tangent d''. The line from *x* to *R* is equal to the plan view of the tangent *cd* and is also equal to the distance *gd*. Radius xp' equals distance *db*. Then triangle *Rxs* is the same as triangle *gdh* and bevel *xsR* is the same as bevel *dhg*. Bevel *xsR*, then, is the required bevel for the lower end of the wreath and bevel *xpR* is the bevel for the upper end of the wreath. Note that bevel *xsR*, in Fig. 154, is the same as angle *dbg* in Fig. 155, and bevel *xpR* in Fig. 154 is the same as angle $xp'r$ in Fig. 155. These bevels represent the angle of inclination of the plane whereon the wreath ascends, a view of which is given in Fig. 155, where the plane is shown to incline equally in two directions. At both ends is shown a section of a rail; and the bevels are applied to show how, by means of them, the wreath is *squared* or *twisted* when winding around the wellhole and ascending upon the plane of the section. The view given in this figure will enable the student to understand the nature of the bevels found in Fig. 154 for a wreath having two equally inclined tangents; also for all other wreaths of equally inclined tangents, in that every wreath in such case is assumed to rest upon an inclined plane in its ascent over the wellhole, the bevel in every case being the angle of the inclined plane.

Third Case. In this example two unequal tangents are given, the upper tangent sloping more than the bottom one. The method shown in Fig. 154 of finding the bevels for a wreath with two equal tangents or two tangents having the same slope, is applicable to all conditions of variation in the inclination or slope of the tangents. In Fig. 156 is shown a case where the upper tangent, d'', slopes more than the lower tangent, c''. The method in all cases is to continue the line of the upper tangent, d'', to the ground line as shown at *g*, and from g draw a line to c which will be the horizontal trace of the plane. Now, from o, draw a line parallel to cg as shown from o to f. Upon f erect a perpendicular line to cut the tangent d'', as shown at m, and draw the line muo''. Make uo'' equal to the length of the plan tangent eo as shown by the arc from o. Put one leg of the dividers on u, extend so that the other point of the dividers will touch the upper tangent d'', and turn an arc over to point *1* on line *eun;* then connect point *1* to o''. The angle or bevel *u1o* at *1* is the bevel to be applied to the upper end of the rough handrail wreath to find the angle between the axis of the handrail molding and the top surface of the

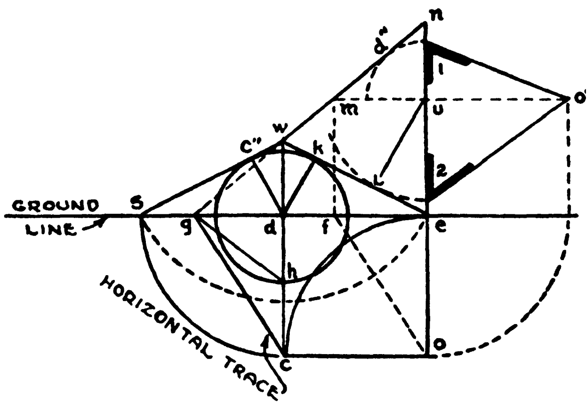


Fig. 156. Method of Finding True Angles for Bevels when Upper Tangent Slopes More Steeply than the Lower Tangent

rough wreath. The line *1u* corresponds to the axis of the handrail mold just as *tu* does at the top of Fig. 155.

Again, place the dividers on point u, extend so that the other point of the dividers touches line L and turn over to point *2* as shown. Connect *2* to o'', and the bevel shown at *2* will be the one to be applied to the lower end of the rough handrail wreath to find the angle between the axis of the handrail molding and the top surface of the rough wreath. The line *2u* corresponds to the axis of the handrail mold just as kL does at the bottom of Fig. 155. It will be observed that the line L represents the lower tangent c''. This line we is the same length as tangent c'' and has a similar slope. An example of this kind of wreath was shown in Fig. 128, where the upper tangent d'' is shown to slope more than the bottom tangent c'' in the top piece extending from h'' to *5*. Bevel *1*, found in Fig. 156, is the real bevel for the end *5,* and bevel *2* for the end *h''* of the wreath shown from *h''* to *5* in Fig. 128.

In order to understand why this last statement is correct, consider in Fig. 156 that, according to the method explained in connection with Figs. 154 and 155, the bevel for the lower end of the wreath can be found by drawing line *dc''* at right angles to, or square with, line *c''* or *sw*. With point *d* as a center swing point *c''* around to point *h*, on line *dc*, and draw line *gh* joining point *h* with the end of the horizontal trace *gc* at point *g*, giving line *gh*. Then the bevel required at the lower end of the wreath is given by the angle *dhg*.

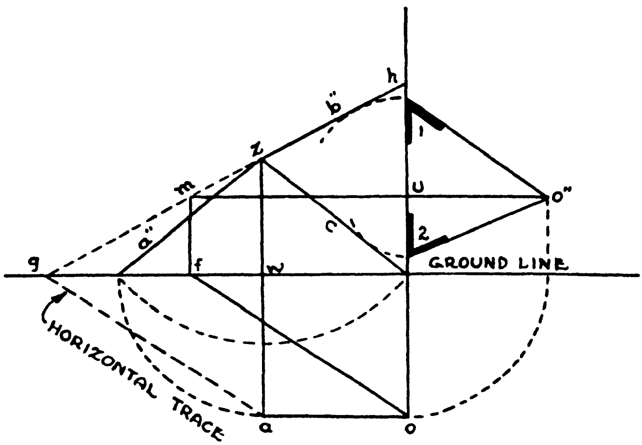


Fig 157. Method of Finding True Angles for Bevels when Upper Tangent Slopes Less Steeply than the Lower Tangent

Now notice that distance *uo''*, Fig. 156, is equal to distance *gf* and that, if *gf* is taken in place of *gd*, *mf* may be taken in place of *wd*, or *ue* in place of *wd*, since *ue* and *mf* are equal. If *ue* can be taken in place of *wd*, *uL* can be taken in place of *dk* or *dc''*, since triangles *wdk* and *wdc''*, and *uLe* are all similar. Further, *uo''* is equal to *eo* and *oc* and *gf*. You have already seen that if *gf* (or *uo''*) is taken in place of *gd*, then *uL* (or *u2*) can also be taken in place of *dk* (or *dh*) and the angle or bevel *u2o''* is the same as the angle or bevel *dhg* and can be substituted for it.

Fourth Case. In Fig. 157 is shown how to find the bevels for a wreath when the upper tangent slopes less than the lower tangent. This example is the reverse of the one considered in connection with Fig. 156 and it is the condition of tangents found in the bottom piece of wreath shown in Fig. 128. To find the bevel, continue the upper tangent b'' to the ground line, as shown at g (Fig. 157) connect g to a, which will be the horizontal trace of the sloping plane. From o, draw a line parallel to ga, as shown from o to f; upon f, erect a perpendicular line to cut the continued portion of the upper tangent b'' in m; from m draw the horizontal line muo'' as shown. Now place the dividers on u, extend to touch the upper tangent zh, and turn over to point *1*; connect point *1* to o''; the bevel at *1* will be the bevel to apply to the end of the rough handrail wreath at its upper end, represented by the upper or right-hand end of tangent b''. Again, place the dividers on u, extend to touch the line c, turn over to point *2*,

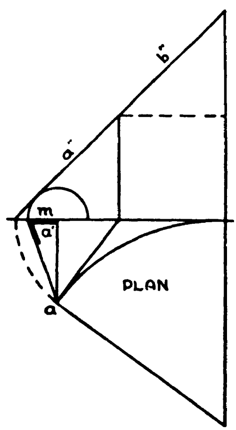


Fig. 158. Finding Bevel where Tangents Incline Equally over Obtuse-Angle Plan

connect *2* to o'', the bevel at *2* will be the one to apply to the end of the rough handrail wreath at its lower end, represented by the lower or left-hand end of tangent a''.

Fifth Case. In this case two equally inclined tangents are over an obtuse angle plan. In Fig. 136 is shown a plan of this kind, and Fig. 137 shows the development of the face mold.

In Fig. 158 is shown how to find the bevel. From a, draw a line to a', square to the ground line. Place the dividers on a'; extend to touch the pitch of tangent a'' and turn over as shown to m. Connect m to a. The bevel at m will be the only one required for this wreath, but it will have to be applied to both ends, owing to the two tangents being inclined. Further explanation on page 185.

Sixth Case. In this case one tangent is sloping and one tangent is level over an obtuse angle plan; that is, the two tangents make an obtuse angle with each other. In Fig. 159 is shown the same plan as in Fig. 158, but in this case the bottom tangent *a* is to be a level tangent. Probably this condition is the most common in wreath construction at the present time. A small curve is considered to add to the appearance of the stair and rail, and in most cases the rail is ramped to intersect the newel at right angles instead of at the pitch of the flight. In such a case, the bottom tangent *a* will have to be a

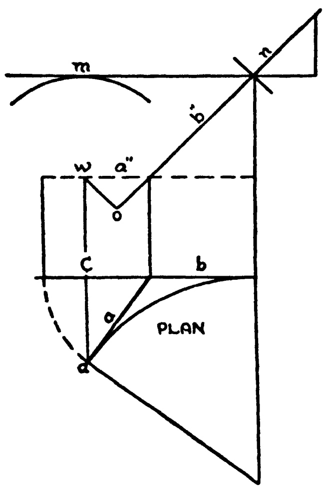


Fig. 159. Same Plan as in Fig. 158 but with Bottom Tangent Level

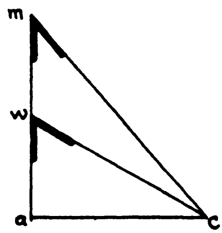


Fig. 160. Finding Bevels for Wreath of Fig. 159

level tangent as shown at *a''* in Fig. 159, the pitch of the flight being over the plan tangent *b* only.

To find the bevels when tangent *b''* inclines and tangent *a''* is level, make *ac* in Fig. 160 equal to *ac* in Fig. 159. This line will be the base of the two bevels. Upon *a*, erect the line *awm* at right angles to *ac;* make *aw* equal to *ow* in Fig. 159; connect *w* and *c;* the bevel at *w* will be the one to apply to tangent *b''* at *n* where the wreath is joined to the rail of the flight. Again, make *am* in Fig. 160 equal the distance shown in Fig. 159 between *w* and *m,* which is the full height over which tangent *b''* is inclined; connect *m* to *c* in Fig. 160, and at *m* is the bevel for level tangent *a''*. Further explanation, p. 187.

Seventh Case. In this case, illustrated in Fig. 161, the upper tangent *b''* is shown to incline, and the bottom tangent *a''* to be level, over an acute-angle plan. The plan here is the same as that in Fig. 133, where a curve is shown to stretch out from the line of the straight stringer at the bottom of a flight to a newel, and is large enough to contain 4 treads, which are gracefully rounded to cut the curve of the central line of rail in *1, 2, 3, 4*. This curve also may be used to connect a landing rail to a flight, either at top or bottom when the plan is acute-angled.

In this case there will be two bevels, in spite of the fact that only one tangent, *b''*, is sloping, while the other tangent *a''* is level, because

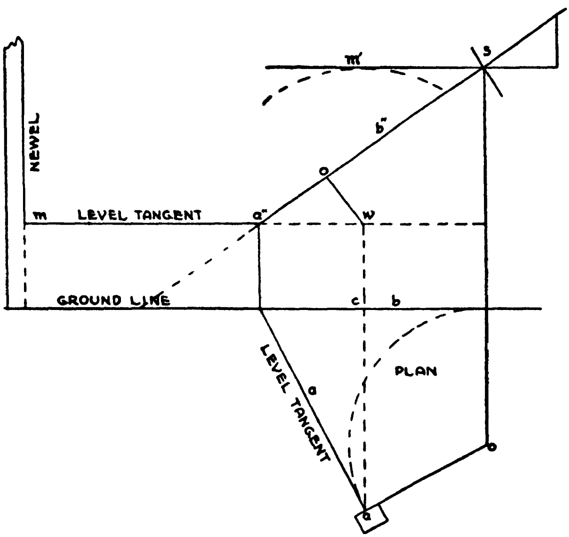


Fig. 161. Upper Tangent Inclined, Lower Tangent Level, over Acute-Angle Plan

the two tangents in the plan view are not at right angles to each other. To find the bevels, make *ac* in Fig. 162 equal to *ac* in Fig. 161 which is a line drawn square to, or in other words at right angles to, the ground line from the newel, and shown in all preceding figures to have been used for the base of a triangle containing the bevel. Make *aw* in Fig. 162 equal to *wo* in Fig. 161, which is a line drawn square to the sloping tangent *b''* from *w*; connect *w* and *c* in Fig. 162. The bevel shown at *w* will be the one to be applied to the upper end of the handrail wreath represented by joint *5* on tangent *b''* in Fig. 161. Again, make *am* in Fig. 162, equal to the distance shown in Fig. 161

between the line representing the level tangent and the line *m'5*, which is the height that tangent *b''* is shown to rise; connect *m* to *c* in Fig. 162; the bevel shown at *m* is the bevel to be applied to the

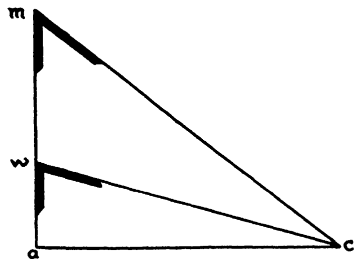


Fig. 162. Finding Bevels for Wreath of Plan in Fig. 161

end of the handrail wreath that intersects with the newel as shown at *m* in Fig. 161.

The wreath is shown developed in Fig. 135 for this case, so that with Fig. 133 for plan, Fig. 135 for the development of the wreath, and Figs. 161 and 162 for finding the bevels, the method is shown for handling any similar case in practical work.

CHAPTER VII

LAYING OUT HANDRAILS AND FACE MOLDS

One problem remaining in connection with the stair shown by the diagrams of Figs. 136 and 137 is to find the height at which the handrail will connect to the face of the newel post. To do this, draw

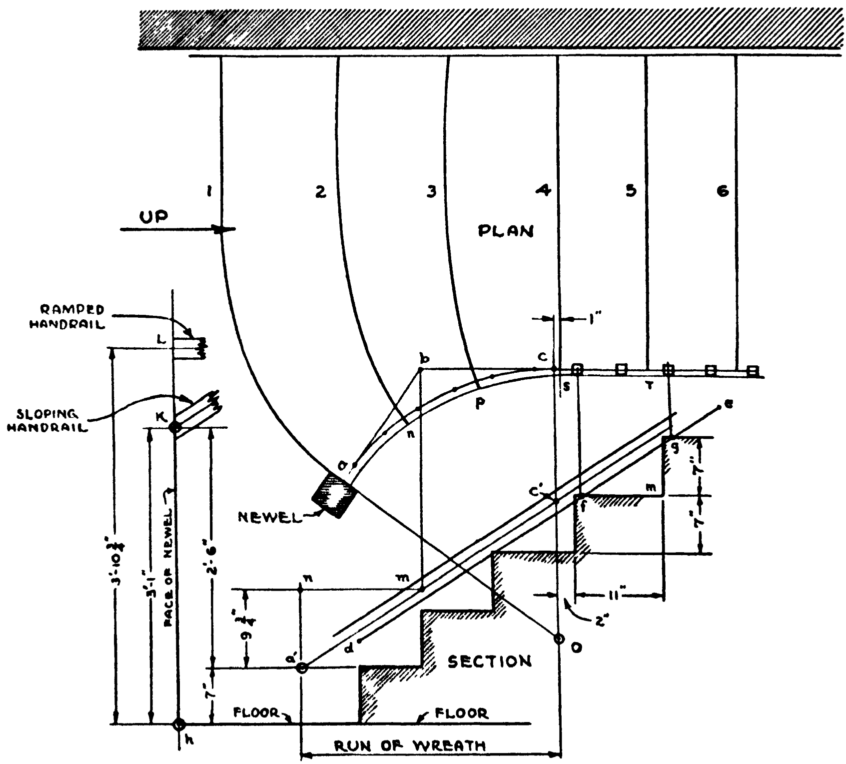


Fig. 163. Diagram of Steps and Handrail over Obtuse-Angle Plan

out the stair in plan and section to scale, as shown in Fig. 163. In the sectional view, locate the points *f* and *g* near the nosings of the steps where the centers of the balusters would intersect the surfaces of the treads. The balusters will be about 2′6″ long and will rise above these points straight up from the surface of the tread to the under surface of the handrail in each case. Therefore, if a line, *de*, is drawn through the points *f* and *g*, it will be parallel to the underside of the handrail and just exactly 2′6″ below it at every point in its length. Now lay off a line representing the center line of the handrail, 1¼ inches above line *de* and parallel to *de*. This line is shown at *a′c′*.

In order that the handrail may slope uniformly downward to the newel post, care should be taken in laying out the stair to make distances *an*, *np* and *ps* along the plan view of the curve of the handrail all equal to distance *sT*. Then the horizontal distance from point *c* to point *a*, at the newel (the run of the wreath) will be found in the sectional view by locating point *c′* on line *a′c′* directly beneath point *c* in the plan view, and measuring off horizontally to the left to point *a′*, a distance equal to the width of three treads less 1 inch. The horizontal curvature of the handrail is laid out from a center at *o*, which lines up with point *c* just 1 inch in front of the nosing of No. *4* riser as shown in the plan view. Point *c* is the point at which the handrail starts to curve, and this explains why it was necessary to subtract 1 inch from the width of the three treads. Point *a′* is on line *a′c′* parallel to line *de* and is just 2′6″ below the center of the handrail where it intersects the face of the newel post, as is shown at the lower left-hand corner of Fig. 163. Point *a′* is also, by measurement, to scale just 7 inches above the floor line. Therefore, the center of the handrail will intersect the face of the newel at a height of 2′6″ plus 7″, which equals 3′1″ above the floor level.

If the handrail were to be ramped so as to flatten out and meet the face of the newel post on the level or at right angles to this vertical face, then at *b*, in the plan view, would be located the point of intersection of the two tangents to the handrail curve, *ab* and *bc*, and projections would be made from *b* down to *m* on line *a′c′* in the sectional view. Since in this case the tangent *ab* would be horizontal, a line *mn* must be drawn in the sectional view, horizontally from *m* to a point directly above point *a′*, at *n*. The distance from *a′* to *n* is found, by measurement to scale, to be 9¾″, and point *n* is 16¾″ above the floor line. Therefore, the intersection of a ramped handrail with the face of the newel will be 2′6″ plus 16¾″, which equals 3′10¾″ above the floor level.

How to Put the Curves on the Face Mold. It has been shown how to find the true angle between the tangents to the curved center line of the face mold, and that the joints at the ends of the wreath, if square with the tangents, will fit the ends of the adjoining parts of the handrail.

Fig. 164 shows how to lay out the curves of the face mold by means of pins and a string, a very common practice among stair builders. In this example, the wreath has equally inclined tangents.

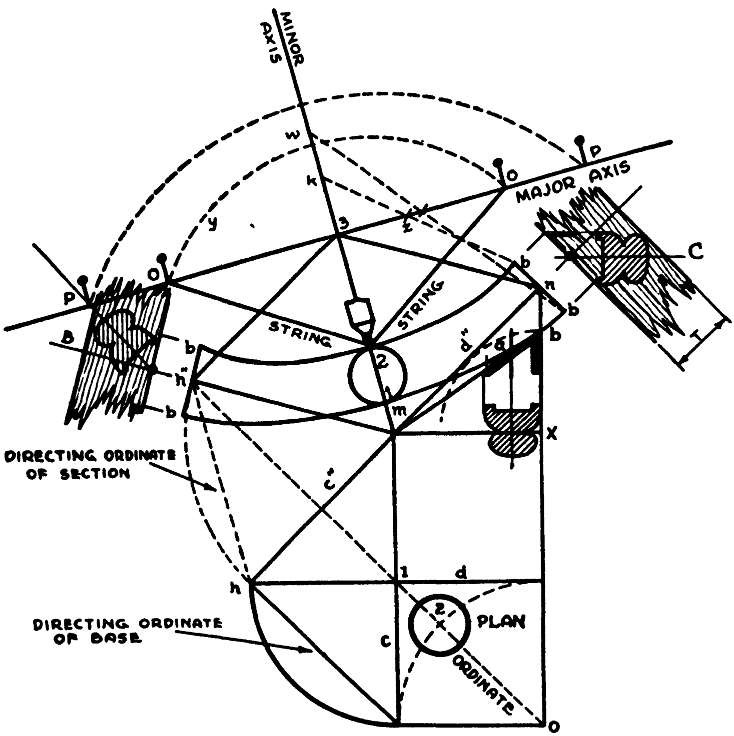


Fig. 164. Laying Out Curves on Face Mold with Pins and String

The lower part of Fig. 164 is similar to Fig. 154. The line marked "H. Trace" in Fig. 154 is marked "Directing Ordinate of Base" in Fig. 164. The line is called Directing Ordinate of Base because a line is drawn parallel to it from point *o* in order to locate point *f*, Fig. 156, and from point *f* are located points *m*, *u* and *o''*, as explained in connection with Fig. 156. In Fig. 164 a line is drawn from point *1* perpendicular to tangent *c''* to *h''* and *h''* is located on this line by swinging an arc from point *h* with point *m* as a center and *mh* or *c''* as radius, until it intersects line *1h''* at *h''*, making line *mh″* equal to *c″* or *mh*. The line *hh″* is called the "Directing Ordinate of Section" and it is useful because a line drawn parallel to *hh″*, starting from point *m*, bisects the true angle between the two tangents. This is shown at *m* near the center of the diagram. This line bisecting the true angle between the two tangents is needed for laying out the face mold and is called the *Minor Axis*. On this line locate point *3*, making the distance *m3* equal to the distance *o1* in the plan view.

A line drawn through point *3* at right angles to the line *m3* will contain the major axes of the ellipses, which will constitute the curves of the face mold. In the plan view draw the circle *2* indicating the width of the handrail molding at this point. If the handrail were of circular cross section, this circle *2* would be a true cross section of it. In the developed view above, draw a similar circle marked *1-2* just as far away from point *m*, along axis *m3*, as the circle of the plan view is distant from point *1* in that view. This circle fixes the width of the face mold at its center. The width of the face mold at each end is fixed by the fact that it must be big enough in all directions so that the finished handrail wreath can be cut from it.

This brings up the question of bevels, that is, the angle which the vertical axis of the handrail section makes with the plane of the top surface of the rough block, or in other words, with the face mold. You have already learned how to find the correct bevels. Refer back to Fig. 154 and note that angle *xpR* gives the bevel for the upper end of the handrail wreath and note that if a line were drawn from *w* to *p*, Fig. 154, then angle *wpx* would be exactly the same as angle *xpR* because $wx = xR$. Also note that triangle *wnx* in Fig. 154, is the same as triangle *mnx* in Fig. 164. In Fig. 164 draw the arc tangent to line *mn* from a center at *x*, and thus get the point *b* on line *on*. Now note that point *b* in Fig. 164 is the same as point *p* in Fig. 154. Then draw line *mb* and thus establish the angle *mbx* which is the bevel for this case where the two tangents slope equally.

Now draw a line at *a*, parallel to line *ob*, and so that the distance between point *a* and line *ob* measured at right angles to line *ob* will be equal to half of the actual width of the handrail molding; then distance *ab* will be half of the width required along the top of the rough block from which the handrail wreath will be cut and will be half of the width required at the ends of the face mold. In the case being considered, of two equally sloping tangents, the width of the two ends of the face mold will be alike because the bevels of the vertical axis of the handrail molding with respect to the plane of the top or bottom of the rough handrail block, represented by the face mold, are alike for both ends of the wreath.

Now take the distance *ab* on the dividers and lay a similar and equal distance off on the joint lines at each end of the face mold both ways from the centers of these joint lines at the ends of the tangents *mn* and *mh''*, as shown at *nb, nb* and *h''b, h''b*. This gives the points

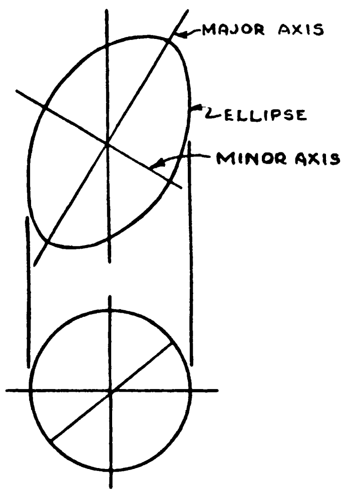


Fig. 165. Comparison of Circle and Ellipse

b, 2, b on the inside line of the face mold curve and the points *b, 1, b* on the outside line of the face mold curve. It is necessary to draw the inside curve through points *b, 2* and *b* and the outside curve through points *b, 1* and *b*. These curves may be assumed to be portions of ellipses or elliptical curves, an ellipse being merely an elongated circle or a circle which has been stretched out in one direction only, like a half lemon as compared to a half orange. This is true because the curve of the handrail wreath is, in plan view, a portion of a circle, but actually it is winding its way up the slope of the stairs, so that one axis of the curve is really longer (being actually on the slope) than the other one is. This principle is illustrated in Fig. 165 and in Fig. 166. In Fig. 164 the face mold curve is rotated around the line *mn* or *d''* so as to show in its true dimensions in the plane of the page, whereas Fig. 166 is an isometric view.

In every ellipse there is a *minor axis* (the shorter one) and a *major axis* (the longer one). To draw out the elliptical curve containing the points *b*, *2* and *b* and the curve containing the points *b*, *1* and *b*, the exact length of the minor and major axes must be

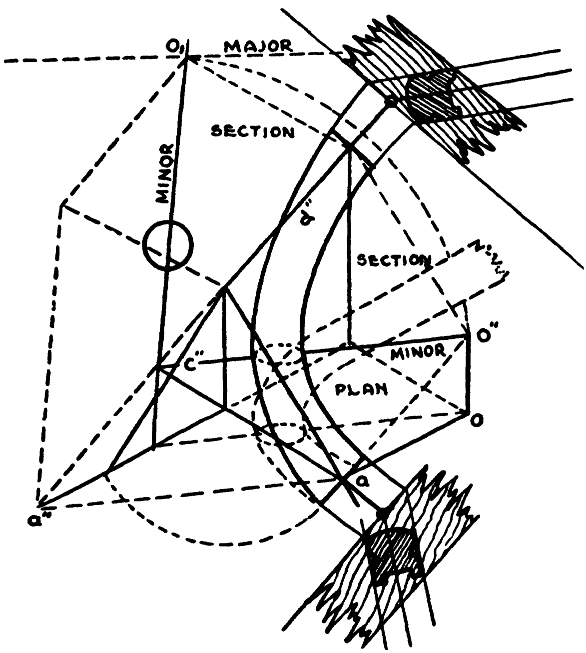


Fig. 166. Isometric View of Face Mold and Tangents and Developed Section of Plane Inclined Unequally in Two Directions

determined. Half of the length of the minor axis for the inside curve, *b2b*, will be the distance shown from point *3* to point *2*; and half the length of the minor axis for the outside curve *b1b* will be the distance shown from point *3* to point *1*. Although these distances are really only the semiaxes, they are spoken of as "the axes."

To find the length of the semimajor axis for the inside curve *b2b*, take the length of the minor axis (distance *3* to *2*) on the dividers. Place one leg of the dividers on point *b* at the inside of the right-hand joint line *bnb*, and draw an arc to cut the major axis *O-3-O* in the point *z*. Draw a line through points *b* and *z*, which will cut the minor axis *2-3* in the point *k*. The distance from *b* to *k* will be the length of the semimajor axis for the inside curve.

To draw the curve, the points or *foci* where the pins or nails are to be placed must be found on the major axis. To find these points, take the distance *bk* (which is, as previously found, the exact length of the semimajor axis for the inside curve) on the dividers, fix one leg of the dividers at point *2* and draw the arc *OwO*, marked *y*, cutting the major axis *O-3-O*, at the points *O* and *O* where the pins are shown. Now take a piece of string long enough to form a loop around the two pins and extend when tight to point *2* where the pencil is shown placed. Keeping the string tight, so that it forms the triangle *O-3-O-2-O*, sweep the curve from *b* to *b* through the point *2*.

The same method for finding the semimajor axis and the *foci* for the *outside* curve is shown in the diagram and is as follows: take the length of the minor axis (distance *3-1*) on the dividers; place one leg of the dividers on point *b* at the outside end of the right-hand joint line, *bnb*, and draw an arc to cut the major axis *O-3-O* near, and to the right of, point *z*. Draw a line through this point and point *b*, which will cut the minor axis *1-2-3* in the point *w*. The distance from point *b* on the outside end of the joint line *bnb* to the point *w*, will be the length of the semimajor axis for the *outside* curve *b1b*.

To draw the *outside* curve, the points, or *foci* (where the pins or nails are to be placed) can be found on the major axis *O-3-O*, by taking the distance *bw* on the dividers, fixing one leg of the dividers at point *1* and drawing the arc *PP*, cutting the major axis *O-3-O* in the points *P* and *P*, where the outside pins are shown. Now, take a piece of string and a pencil and loop the string around the *outside* pins, *P* and *P*, and the pencil, when the pencil point is at point *1*, so that the string will form a triangle around the pins and the pencil, and, keeping the string taut, sweep the curve from *b* to *b* through the point *1*.

A simpler way to lay out the curves of the face mold for a handrail wreath is shown in Fig. 167. Referring to Figs. 124 and 127, the position of the two tangents to the upper wreath, *c''* and *d''*, is shown in their true relation to each other as they are in Fig. 167, and the method of laying them out is explained. In Fig. 167 draw out the lines representing the tangents *c''*, *d''* and *h''m* in their correct relation to each other and in their true lengths. Draw the "Directing

Ordinate" *hh''* and from point *m* draw the minor axis *mz* parallel to *hh''*. From the layout shown in Fig. 124 get the distance *od* in the plan view and in Fig. 167 locate the major axis a similar distance from point *m*, at *z*, along the minor axis *m2*. Also locate on the minor axis the center of the circle *1-2* on the center line of the curve of the face mold at point *p*, corresponding to point *p* in Fig. 124, making the distance *mp* equal to the distance *dp* in Fig. 124.

Now select the molding desired or specified for the handrail and draw the small circle with center at *p*, Fig. 167, and with diameter

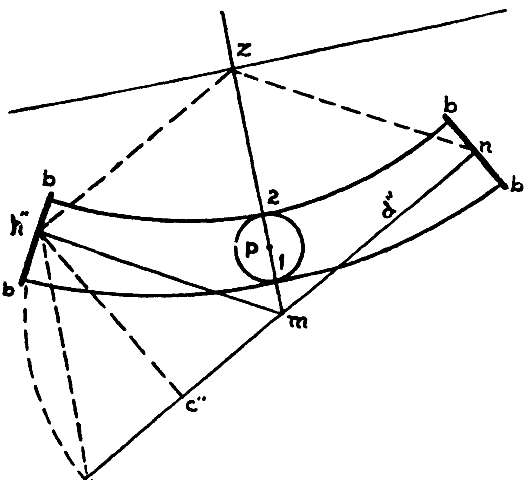


Fig 167. Simple Method of Drawing Curves on Face Mold

equal to the width of the handrail molding. Draw the joint lines *bh''b* and *bnb* at the ends of the two tangents, and at right angles to them, and determine the width of the face mold at the ends *bh''b* and *bnb* by means of the bevels, as was explained in connection with Fig. 164.

Now, with points *b, 2* and *b* located, take a flexible lath and bend it to touch *b, 2* and *b* to give the line of the inside curve and bend a lath to touch points *b, 1* and *b* for the outside curve. This method is handy where the curve is comparatively flat, as in the example here shown, but where the mold has a sharp curvature, as in the case of the curve shown in Fig. 133, the method shown in Fig. 164 must be used.

The methods for laying out the curves of the face molds of the handrail wreaths for Figs. 164 and 167 are explained, but it is also necessary to know the thickness required for the piece of plank from which the wreath may be carved. This is shown at *B* and *C* in Fig. 164. In Fig. 166, the view of the face mold given is a top view, that is, you are looking at the top of the handrail wreath, but Figs. 164 and 168 show the plane of the wreath revolved about the line *hn*

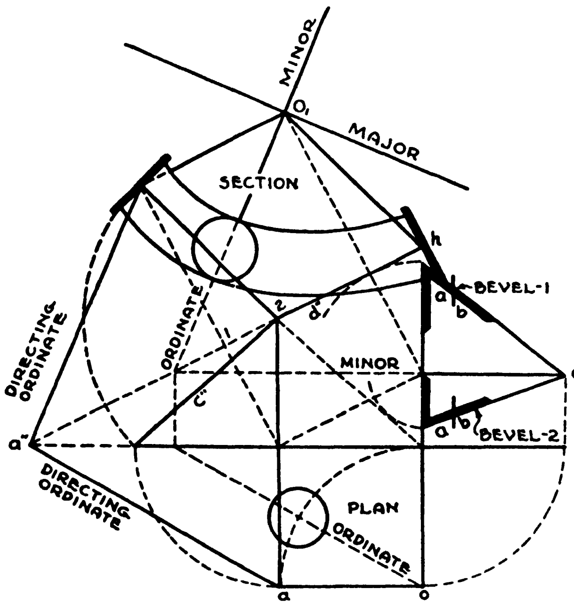


Fig. 168. Tangents, Bevels, Mold Curves, etc., from Bottom Wreath of Fig. 128 in which Upper Tangent Inclines Less than Lower One

and *h2*, respectively, so that the view of the face mold there given is a view looking at the *underside* of the rough block from which the finished molding for the handrail wreath is to be carved.

As explained before, in order that the top of the handrail mold may be always uppermost for the hand to rest on in going up the staircase around the turn of the stairs, the molding of the handrail wreath will have the appearance of being *twisted* and the axis of the molding will be on a bevel with reference to the top or bottom surfaces of the rough block or face mold. At *B*, Fig. 164, is shown the outline of the molding drawn out on the lower end of the rough wreath with the axis of the molding at the proper bevel (found by methods already explained) with the face mold. At *C* is shown the molding for the upper end of the wreath drawn out on the end of the rough wreath. The axis of the molding is shown to be at a bevel with reference to the plane of the face mold. In both these cases, that shown at *B* and that shown at *C*, the outline, or the design, of the handrail molding and its bevel determine the necessary thickness of the plank from which the wreath is to be cut, as shown at *T*.

The face mold shown in the two diagrams, Figs. 164 and 167, is for the upper wreath extending from *h* to *n* in Fig. 126. A practical workman would draw out only what is shown in Fig. 167. He would take the lengths of tangents from Fig. 124 and place them as shown at *h''m* and *mn*. By comparing Fig. 167 with the tangents of the wreath in Fig. 124 it will be easy to understand the remaining lines shown in Fig. 167. With one point of the dividers or compasses on point *m*, take the distance *hm* equal to tangent *C''* in Fig. 124 and draw the arc *hbh''*. As yet the position of the upper point *h''* on this arc is not known, but if the line *c''h''* is drawn at right angles to tangent *c''*, or line *mh*, at its central point, it will pass through the arc *hbh''* at point *h''*, thus fixing the location of this point. Once this point is fixed, the line *mh''* can be drawn, and the joint line *bh''b* can be drawn at right angles to line *mh''*. Joint *bnb* is drawn at right angles to line *mn*. Distances *nb* and *h''b* are found by the methods explained in Fig. 164. Then curves *b2b and b1b* can be drawn with a bent lath as already explained.

In Fig. 168 are shown the tangents *c''* and *d''*, similar to the bottom wreath tangents *a''* and *b''* in Fig. 128. The lower part of Fig. 168 is similar to Fig. 157 except that the *horizontal trace* in Fig. 157 is called a *directing ordinate* in Fig. 168 and the lettering is different. With point *2* as a center and the length of the tangent *c''* as radius, draw the arc with the dividers or compasses and locate the joint line of the wreath by drawing a line at right angles to line *a''–1–2* through point *1* from the point of intersection of the plan view of the two tangents. The intersection of this line with the arc fixes the end of the face mold, and a line drawn from this intersection to point *a''* is the *directing ordinate of the section.* The lines marked "Ordinate" which fix the location and direction of the minor axis are drawn parallel to the directing ordinates starting from the point *o*.

From this point on, the procedure is similar to that explained in connection with Figs. 164 and 167. The bevels are found as explained in connection with Figs. 157 and 156. Fig. 166 shows in isometric view the face mold of Fig. 168 in its natural position directly over the plan view. It shows this face mold starting at point *a*, where it joins the straight, sloping handrail of the straight flight and winding upward around the curve of the wellhole in the direction of the two unequally sloping tangents. The curved wreath ends at the upper end of the tangent d'' where it joins the straight, sloping handrail of the upper straight flight. The dotted lines marked "plan" show an isometric of the plan view of the face mold. The curved full lines show an isometric view of the face mold as it lies in the sloping plane of the handrail wreath, unequally inclined in two directions with respect to the horizontal plane. This sloping plane also contains the minor axis, $c''o''$, and the two tangents to the center line of the curved face mold, one of which is d'' and the other tangent starting to slope up at *a* and meeting the lower end of tangent d''. The upper part of Fig. 166 shows the triangle formed by the minor axis (marked "minor" in the figure) and the tangent d'', rotated about line d'' up and around into the plane of the page. Only the minor axis is shown in its new position in the upper part of Fig. 166 but the face mold is rotated as well, and this face mold is shown in its new position in the upper part of Fig. 168. In Fig. 166 you are looking at an isometric view of the top of the handrail wreath and the upper surface of the face mold, but in Fig. 168 you are looking at a true view of the underside of the face mold because it has been rotated up and over about line d'' as an axis.

A STAIRWAY OF AN EARLY ENGLISH CHARACTER

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

CHAPTER VIII

HOW TO LAY OUT STAIRS TO SIMPLIFY HANDRAIL PROBLEMS

Arrangement of Risers in and around Wellhole. In wreath construction for geometrical stairways it is important that the workman or the designer have a knowledge of how best to arrange the risers of the stairs in and around the wellhole. A great deal of labor and material may be saved through it, and the appearance of the finished handrail may be much improved.

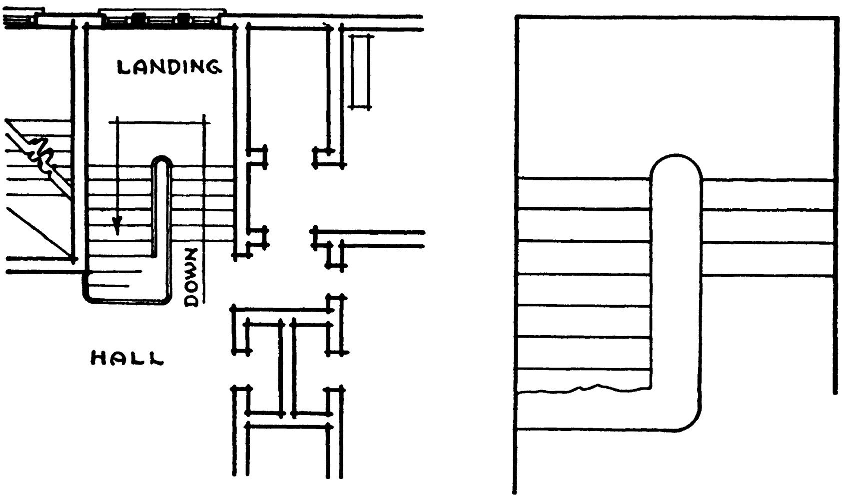


Fig. 169. Plan of Stair with Landing and Return Steps

In stairways which have an intermediate landing at the end of the wellhole as shown in Fig. 169, with a continuous handrail around the wellhole and no newel posts, the simplest and easiest arrangement is the one shown in Fig. 170 in which the radius of the center line of the handrail in plan is made equal to half the width of a tread. In the diagram, Fig. 170, the radius is shown to be 5″ and the width of the tread 10″. The risers are placed one-half the tread width (in this case 5″) back from the end of the wellhole and as the radius of the wellhole is in this case 5″ (which is half the width of the tread) the risers come at the springing of the curve of the end of the wellhole in plan, that is, at *a* and *a* in Fig. 170 where the straight part of the wellhole in plan stops and the curved part begins. The elevation view of the tangents by this arrangement will be as shown in Fig. 170, one level and one inclined for each piece of wreath, because there are no risers at the end of the wellhole and consequently the two tangents to the curve of the handrail, which meet at the center of the curve, are both level. Under these circumstances, there is no trouble in finding the angle of the tangent, as required for the face mold, because that angle

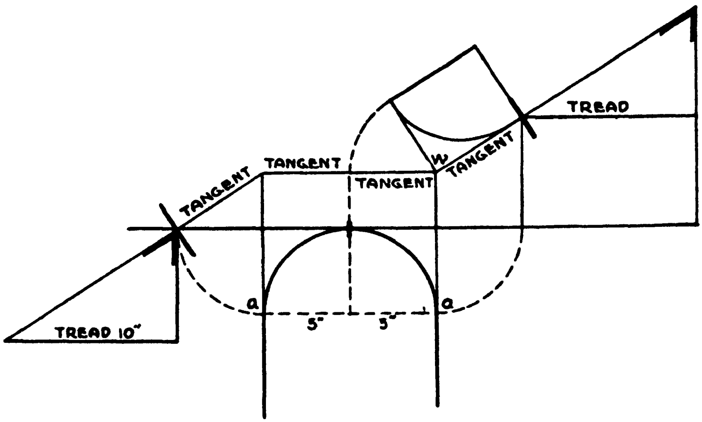


Fig. 170. Arranging Risers around Wellhole on Level-Landing Stair, with Radius of Central Line of Rail Equal to Half Width of Tread

in every such case is a right angle as shown at *W*, Fig. 170. No special bevel will have to be found, because the upper bevel of the pitchboard gives the angle required for both bevels.

When the radius of the center line of the handrail in plan is larger than half the width of a tread, as shown in Fig. 171, results similar to those obtained in the last example can be achieved by placing the riser, *a*, at a distance back from the end of the wellhole equal to half the width of the tread (the same as shown in Fig. 170) although in this case (Fig. 171) the springing of the wellhole curve in plan is farther back from the end of the wellhole, due to the fact that the radius of the wellhole curve is greater than half the width of a tread. This of course fixes the width of the landing and the position of all the steps with reference to the curved end of the wellhole.

Fig. 172 shows, in plan and section, the same geometrical stair which is shown in diagram in Fig. 170 and is presented to illustrate the advantages of placing the first risers back from the semicircular end of the wellhole a distance equal to half the width of a stair tread. In Section *A-A* the handrail is shown 2′9″ above the tread of the stair at the landing, with the treads 10″ wide and risers 7½″ high. As the sloping handrail passes over the width of one tread, or 10″, it falls a distance equal to the height of one riser or 7½″. If the tangent to the curve of the handrail wreath (*de* in the plan view and

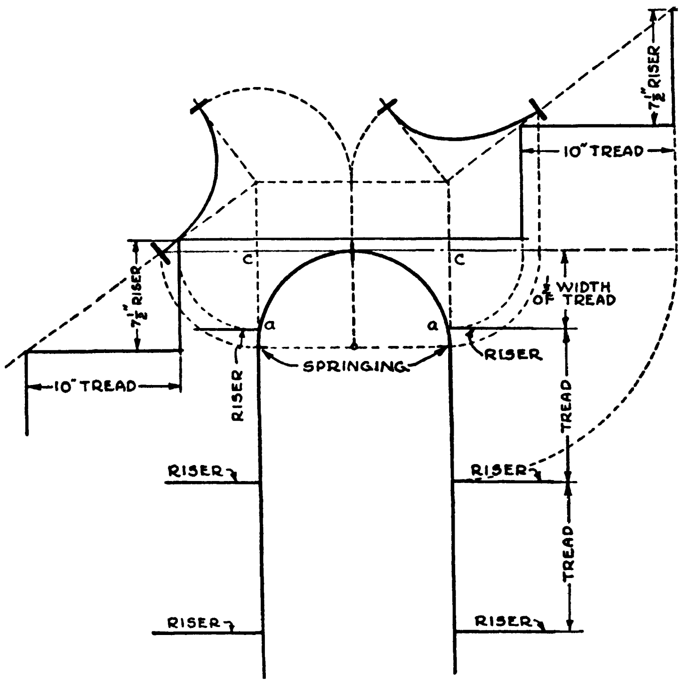


Fig. 171. Arrangement of Risers around Wellhole Having a Radius Larger than Half Width of Tread

wn in Section *A-A*) is given the same inclination as the sloping handrail, and if the distance *dc* in the plan view is equal to one-half of the tread width, then the handrail in passing from *e* to *c* in the plan view will fall one-half the height of a riser and in passing from *c* to *a* in the plan view (as shown also in Section *B-B*) will fall again one-half the height of a riser, making a total fall of one full riser height in passing around the semicircular curve from *e* to *a* in the plan view. The height of the handrail above the landing will therefore be 3′4½″ at point *e*, 3′¾″ at point *c* and 2′9″ at point *a*. As point *a* is at the nosing of the first step at the edge of the landing, this height of 2′9″ from landing to handrail at this point is correct and corresponds to the height of 2′9″ at point *e* as shown in Section *A*-*A* at *n*. The height of

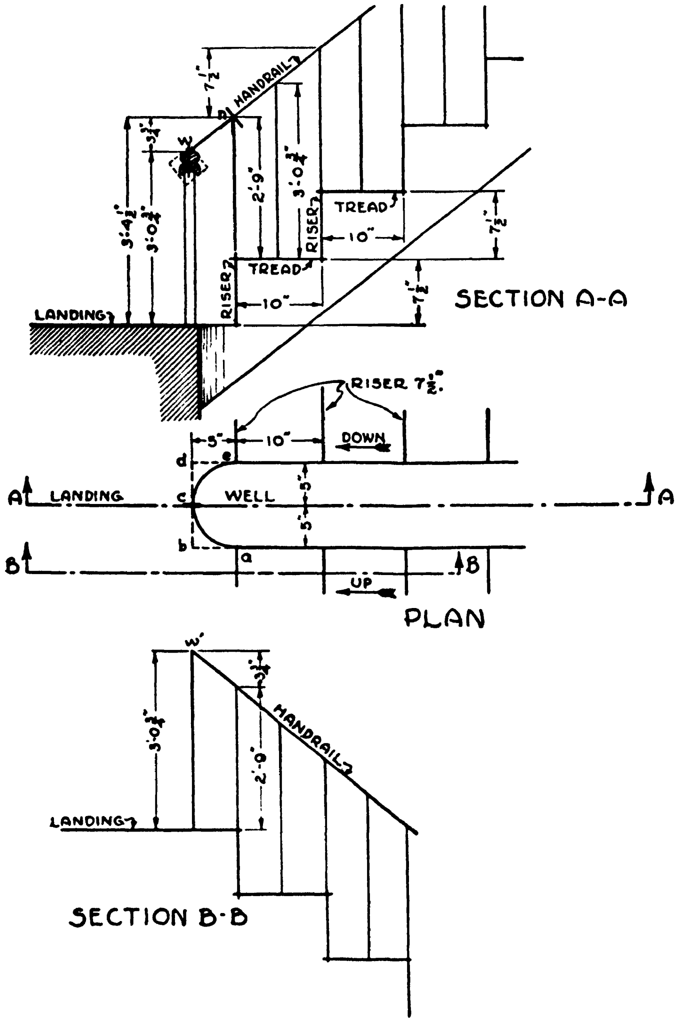


Fig. 172. Plan and Sections of Geometrical Stair Showing how Risers Should Be Placed

3′¾″ from landing to handrail at point *c* in the plan view and as shown in Section *A*-*A* at *W*, corresponds to the vertical distance between the center of any tread and the handrail as shown in Section *A*-*A*. This is as it should be and, besides, the inclination of the tangents has been kept the same as the slope of the handrail, which is a great advantage since it makes it much easier to lay out the face mold of the handrail wreath.

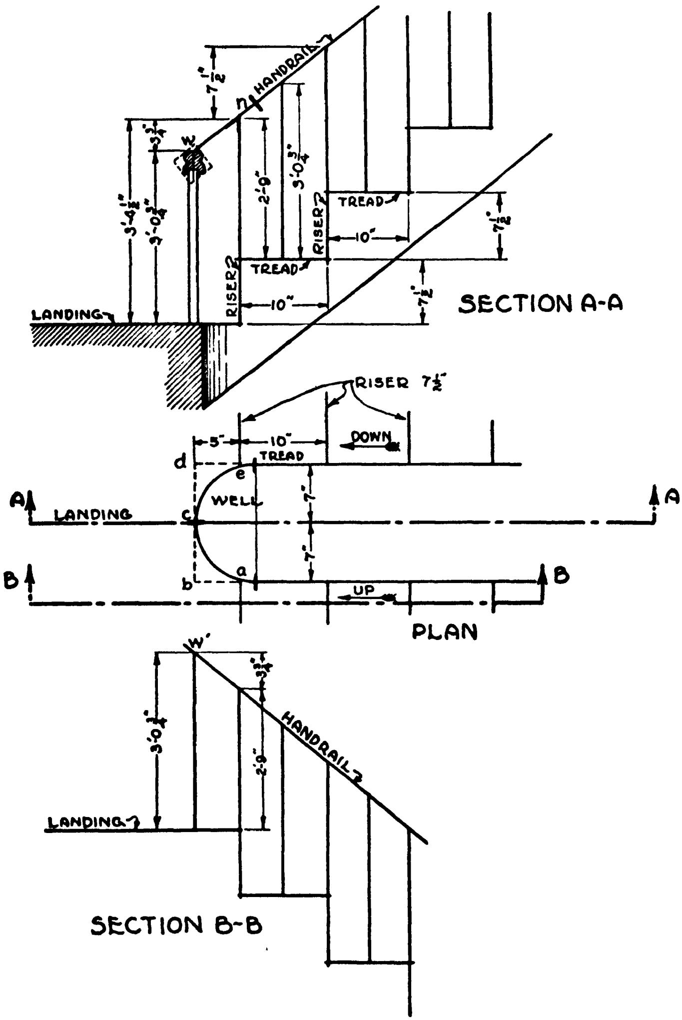


Fig. 173. Plan and Sections of Geometrical Stair with Wellhole Wider than the Tread Width

If the wellhole is made wider than the width of one tread, it will not change any of these figures or interfere with the advantages gained, so long as the distances *de* and *ba* in plan view remain equal to one-half the width of a tread. The only effect will be to move the joint in the handrail farther away from the end of the wellhole as shown in Fig. 173, since this joint usually is placed at the point where the handrail starts to curve around the end of the wellhole, that is, at the springing. But if the risers at the edge of the landing at *e* and *a* in the plan view are placed at a greater distance than half the tread width from the end, *c*, of the curved wellhole, then the tangents can no longer each have an inclination equal to the handrail slope. The joint

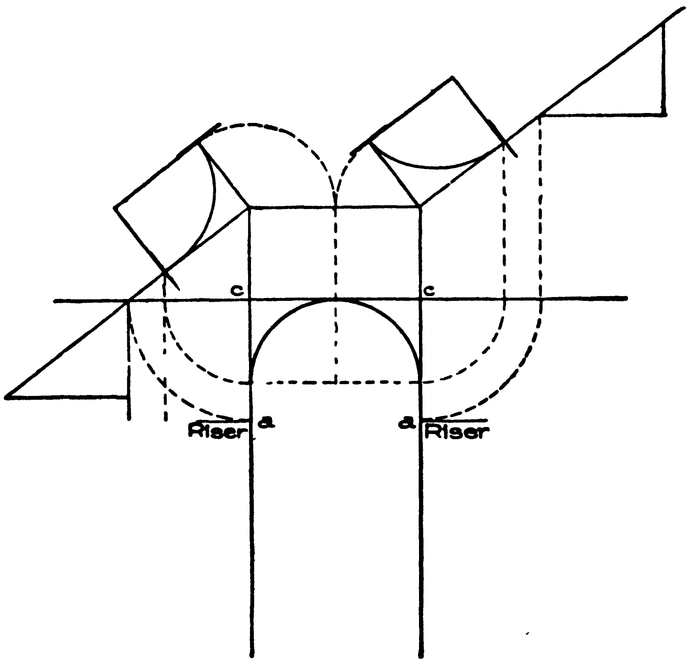


Fig. 174. Arrangement of Risers around Wellhole, with Risers Placed Full Width of Tread Back from End of Wellhole

in the handrail will always be placed at a point corresponding to the springing of the curve of the wellhole, and this is at a distance back from the curved end of the wellhole in plan equal to the radius of the wellhole curve.

If the risers at the edge of the landing are placed (in plan view) a distance equal to one-half a tread width from the end of the curved wellhole, then the *tangent* to the curved handrail wreath will have the same *inclination* as the regular slope of the straight part of the handrail. Note that this is true of *the tangent* to the handrail and not the entire curved handrail itself. The handrail wreath will start out at the point *n* (at its upper end) with the same slope as the straight part of the handrail but, on account of the level landing, the handrail must be horizontal at the center of the landing (at point *c*, Fig. 173) and therefore it will gradually flatten out as it slopes down towards the point *c* until at this point it is absolutely level and flat. Then it will start to slope downward gradually again as it continues around the curved wellhole, until at the point *a*, Fig. 173, it will again have the same slope as the straight part of the handrail for the lower flight of the stairs. This is necessary to make the handrail serve a person standing on the level landing as well as a person ascending the stairs. Obviously the handrail at the center of the curved edge of the level landing must be level (not sloping).

In Fig. 174 is shown a case where the risers at *a* are placed at a distance from *c* equal to a full tread. This is not a desirable arrangement for the following reasons: the handrail will be at the usual height (about 2′9″) above the level of the tread at *a* on the right-hand side of the figure where the stair is sloping downward toward the landing, and it is therefore, at this point, 2′9″ plus one riser height above the level of the landing. If the handrail continued to slope downward towards the landing at its regular inclination (that is, at the same slope as the stair itself) it would fall one riser height in the distance *ac* which is equal to one stair tread. Therefore the handrail would be only 2′9″ above the landing level at the center of the curved end of the wellhole. From this point it would continue to fall at the same rate in passing around the quarter circle of the wellhole to a position above the riser at point *a* on the left-hand side of Fig. 174, and in traversing the distance *ca* its height above the landing level would again be reduced by the height of one riser (about 7½ inches) since *ca* equals one tread. This would bring the handrail height above the riser at *a* on the left-hand side of Fig. 174 down to about 2′1½″, whereas it should be 2′9″ at this point, the same as elsewhere.

The only way to avoid this is to ramp the handrail at points *a* out to a level position by means of easements and to carry it around the semicircular end of the wellhole at a level (that is in a horizontal plane) at a height of about 3′ above the landing level between the two points marked *a* in Fig. 174 by the use of two quarter turns, each in the form of a quarter circle. This arrangement is possible and avoids the necessity for a twisted handrail wreath, but the appearance of the stair is not so pleasing as the arrangement shown in Figs. 172 and

173. Fig. 175 shows in plan and elevation a handrail wreath arranged as that described for a geometrical stair where the first risers at the level landing are located a full tread width back from the curved end

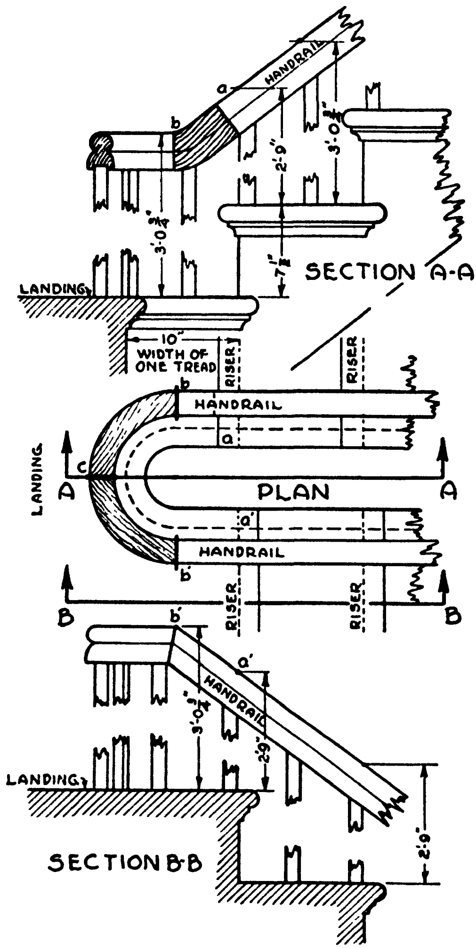


Fig. 175. Geometrical Stair Showing Treatment of Handrail about Wellhole and Placement of Risers

of the wellhole. At the face of these first risers the top of the handrail is 2′9″ above the top surface of the tread, and it is 3′0¾″ above the center of the first tread, due to the slope of the handrail. The entire *landing* (to the left of the points *a* and *a′* in the plan) is level, and the top of the handrail should follow around the landing at a level about 3′0″ above this landing from the point *b*, where it starts to curve in plan to point *b′*. At point *b* (Section *A-A*) it will be about 3′0″ above the landing and will be level, while at point *a*, Section *A-A*, it will be 2′9″ plus the height of one 7½-inch riser or 3′4½″ above the landing level and will be sloping; therefore it will be necessary to insert a piece of handrail that is curved in the vertical plane to join

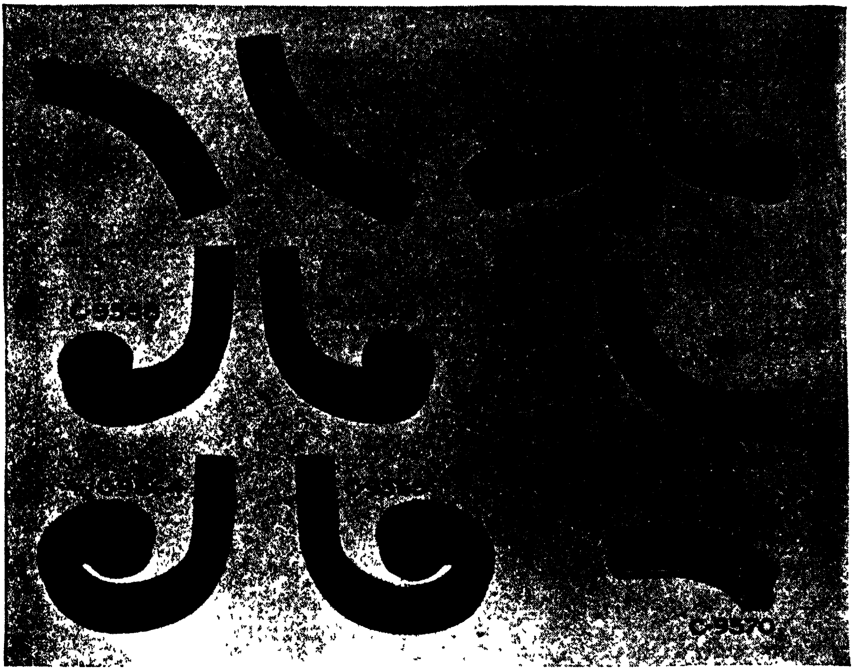


Fig 176. Stair Crooks

Courtesy of Curtis Companies, Incorporated, Manufacturers of Curtis Woodwork, Clinton, Iowa

the sloping part of the handrail on the stairs to the level part of the handrail on the landing. This piece *ab*, Section *A-A* of Fig. 175, is called an *Up Easing* or *Up Easement*. A similar easement, but of a somewhat different shape, is required between points *b′* and *a′* in the plan view where the stair starts to go down from the level landing, as is shown at *b′* in Section *B-B* of Fig. 175. At *b′* the handrail will be about 3′0″ above the level landing and will be level, while at *a′* it will be 2′9″ above the level landing and will be sloping downward to join the sloping handrail of the lower flight. When the first risers are one tread width back from the end of the wellhole, only a simple miter is required at point *b′* as is shown in Fig. 175, but if the first risers were still further back, a curved piece of handrail called an *Overhead Easing* or *Overhead Easement* would be inserted at this point. (See *C-9550,* Fig. 176.)

Between points *b* and *c* in the plan view Fig. 175 the handrail will remain level at a height of about 3′0″ above the level landing and follow around the curved edge of the landing at the semicircular end of the wellhole in the form of a quarter circle. There will therefore be required at this point a piece of handrail curved in a horizontal plane

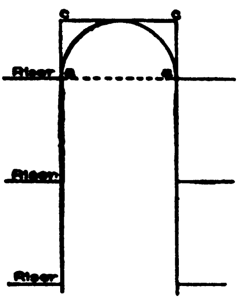


Fig. 177. Plan of Stair Shown in Fig. 170

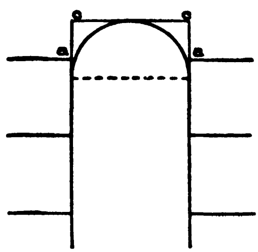


Fig. 178. Plan of Stair Shown in Fig. 171

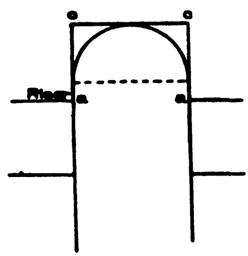


Fig. 179. Plan of Stair Shown in Fig. 174

as shown at *bc* in the plan view and called a *Level Quarter Turn.* (See *C-9570,* Fig. 176.) A similar level quarter turn will be required between the points *c* and *b′* in the plan view, thus completing the handrail around the curved end of the wellhole at the edge of the landing. In Fig. 176 are illustrated some of the easings and quarter turns which are carried in stock by manufacturers and dealers in architectural woodwork.

At *C-9555* is shown an *Up Easing* designed to connect a sloping handrail with a level rail. At *C-9550* is shown an *Overhead Easing.* At *C-9570* is shown a *Level Quarter Turn.* At *C-9560* is shown a *90-Degree Easing* designed to connect a horizontal handrail with a vertical rail. At *C-9556, C-9557, C-9558* and *C-9559,* are shown two different designs of right- and left-hand *Turnout Easings* for use at the foot of staircases where there are small newel posts. At *C-9564* and *C-9565* are shown more elaborate easings called *Volutes,* also designed for use at the foot of Colonial staircases of the type shown in Fig. 189.

In Fig. 177 is shown the plan of Fig. 170, in Fig. 178 the plan of Fig. 171, and in Fig. 179 the plan of Fig. 174. In all these figures the only bevel required will be the one which is given by the upper angle of the pitchboard for the steps, which is shown in Fig. 170. This type of wreath also is the one that is required at the landing at the top of a

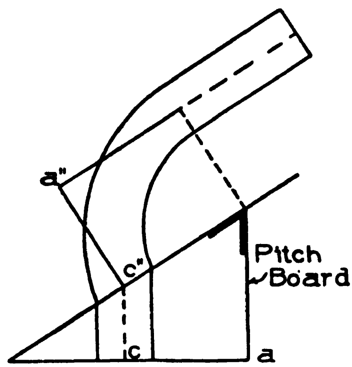


Fig. 180. Drawing Face Mold for Wreath from Pitch-Board

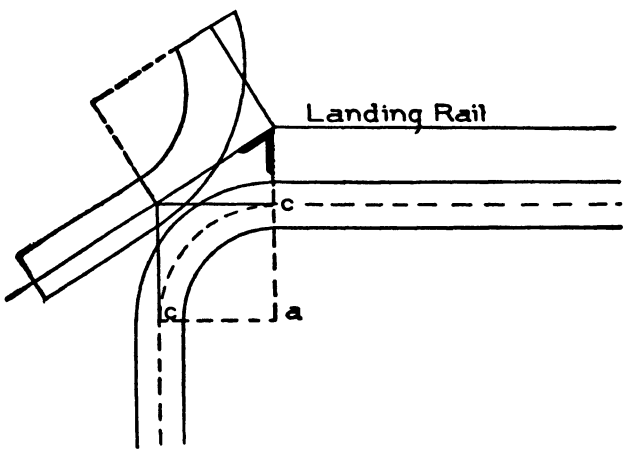


Fig. 181. Development of Face Mold for Wreath Connecting Rail of Flight with Level Landing Rail

flight of stairs when the handrail of the flight intersects with a level landing rail.

In Fig. 180 is shown a very simple method of drawing out the face mold for this wreath from the pitchboard. Fig. 181 shows the face mold developed in the usual way with the distance from point *c* to the line marked *"Landing Rail"* bearing the same relation to the stair riser as the distance *ca* bears to the stair tread, so that the triangle at the left-hand end of the line marked *Landing Rail* is similar to the triangle of the pitchboard. It will be noted that the upper end of the face mold in Fig. 181 is wider than the lower end; just how much wider it should be depends upon the bevel, which in this case is the same as the angle at the upper end of the pitchboard.

In Fig. 180 draw out the triangle of the pitchboard to full size, or to scale, with the lower horizontal line equal in length to the width of a stair tread and the vertical side equal in length to the stair riser.

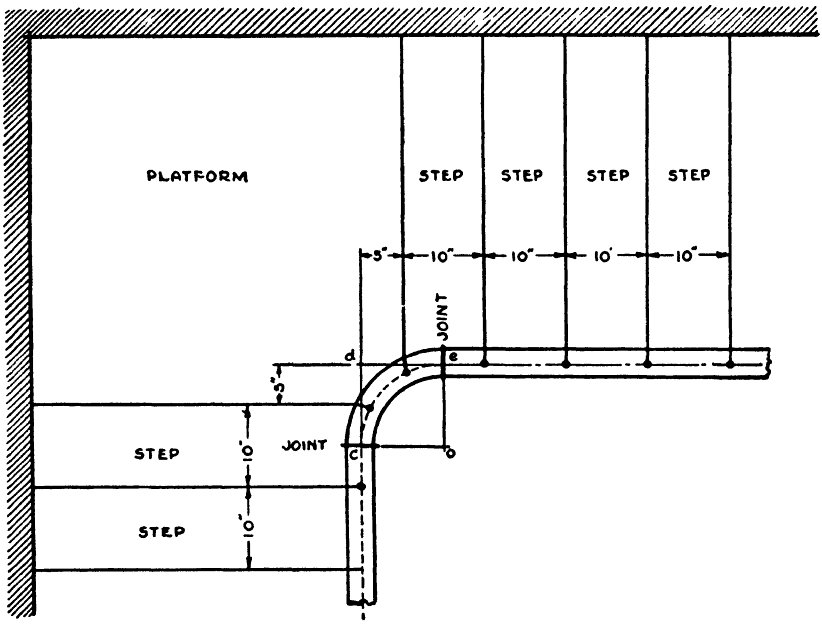


Fig. 182. Arranging Risers in Quarter Turn between Two Flights

The sloping side joins the two outer ends and forms the angle or bevel which is shown by heavy black lines. Now the rectangle enclosing the face mold in Fig. 181 can be revolved about the center with the face mold on it until the wide upper joint of the face mold rests against the sloping side of the pitchboard as shown in Fig. 180. To draw this out make *ac*, Fig. 180, equal to the radius of the central line of the curve of the handrail in the plan view Fig. 181, and lay this distance off on the horizontal side of the pitchboard from the corner, *a*, in Fig. 180. Now draw *cc''* parallel to the vertical side of the pitchboard, with the lines on each side of *cc''* representing the true width of the handrail. The points in which these lines cut the sloping side of the pitchboard determine the width of the wider end of the face mold as shown in Fig. 180. From where line cc'' cuts the long sloping side of the pitchboard, the line $c''a''$ is drawn at right angles to the sloping side, and distance $c''a''$ is made equal to the length of the plan tangent ac of the handrail curve shown in Fig. 181. The rectangle of the face mold is completed as shown in Fig. 180, and the width of the upper end of the face mold (which was the lower end in Fig. 181)

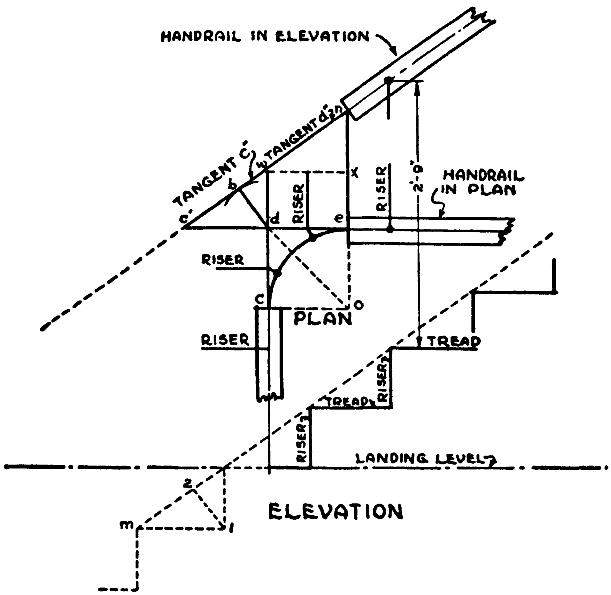


Fig. 183. Arrangement of Risers around Quarter Turn Giving Tangents Equal Pitch

is determined from the true width of the handrail. Then the face mold can be completed by means of a trammel.

In Fig. 182 is shown a quarter turn between two flights. The correct method of placing the risers in and around the curve is to put the last one in the first flight and the first one in the second flight one-half a step from the intersection at d of the two tangent lines cd and de in plan. By this arrangement, as shown in Fig. 183, the pitch line of the tangents c'' and d'' of the handrail will equal the pitch or slope of the stairs because the tangent d'' in traversing the distance de (equal to the width of one tread) in plan, falls through a distance equal to the height of one riser. Point d on the handrail tangent will be set at the same distance above the platform level that point e on the handrail is above the step, and likewise point *d* on the handrail tangent will be at the same height above the platform that point *c* on the handrail is above the lower step. This arrangement gives the second easiest condition of tangents for the face mold—namely, as

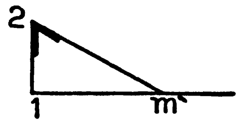


Fig. 184. Finding Bevel for Wreath of Plan Fig. 182 and Fig. 183

shown in Fig. 183, two equal tangents. For this wreath only one bevel will be needed and it is made up of the radius of the plan central line of the handrail *oc*, Fig. 183 (which is equal to one tread width *m1*) for a base and the line *db* (which is equal to distance *1-2*, Fig.

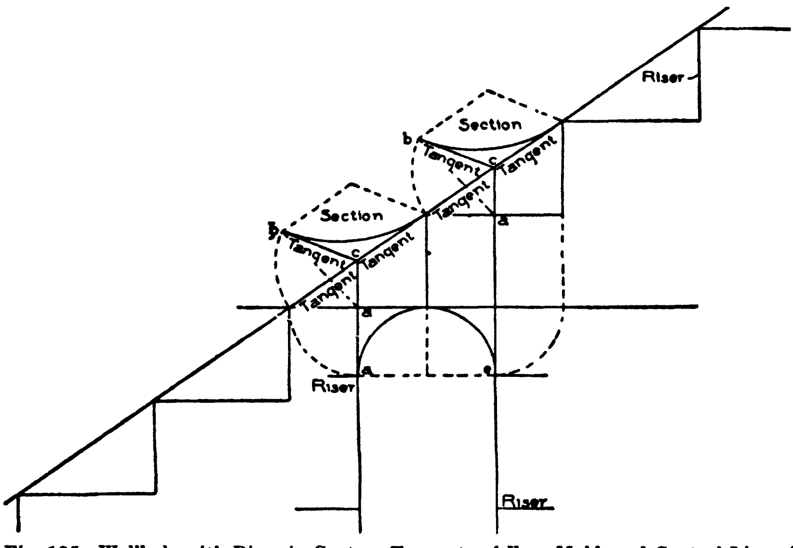


Fig. 185. Wellhole with Riser in Center; Tangents of Face Mold, and Central Line of Rail, Developed

183) for altitude, as shown in Fig. 184. The bevel shown in this figure has been previously explained in connection with Figs. 154 and 155. It is applied to both ends of the wreath. In Fig. 183, *db* is perpendicular to tangent *c''* and line *2-1* is perpendicular to the line joining the nosings of all the steps.

The example shown in Fig. 185 is of a wellhole having a riser in the center. If the radius of the plan central line of rail is made equal to one-half a tread, the pitch of tangents will be the same as of the flights adjoining, thus securing two equal tangents for the two sections of wreath. In this figure the tangents of the face mold are developed

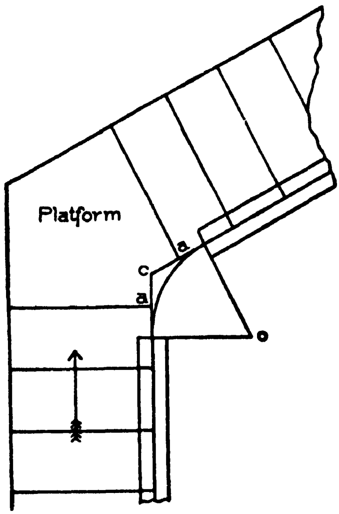


Fig. 186. Arrangement of Risers in Stair with Obtuse-Angle Plan

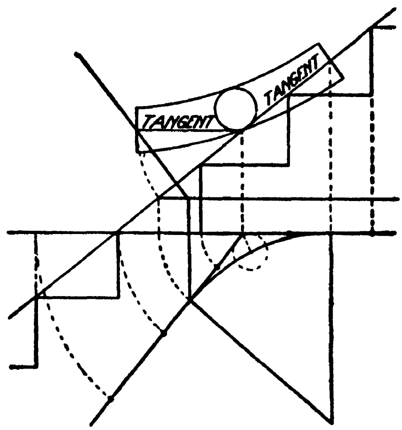
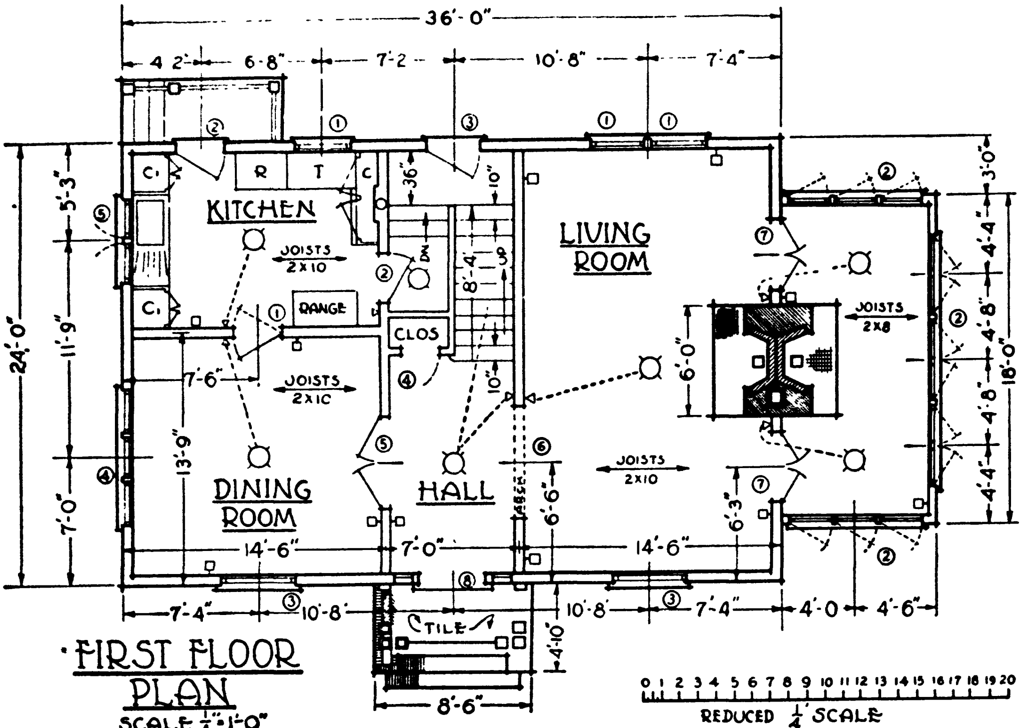


Fig. 187. Arrangement of Risers in Obtuse-Angle Plan, Giving Equal Pitch over Tangents and Flights; Face Mold Developed

and also the central line of the rail, as shown over and above each quadrant and upon the pitch-line of tangents.

The same method may be employed in stairways having obtuse-angle and acute-angle plans, as shown in Fig. 186 where two flights are placed at an obtuse angle to each other. If the risers shown at *a* and *a* are placed one-half a tread from *c*, this will produce, in the elevation, a pitch-line over the tangents equal to that over the flights adjoining, as shown in Fig. 187 in which also is shown the face mold for the wreath that will span over the curve from one flight to another.



FIRST FLOOR PLAN

SCALE $\frac{1}{4}$" = 1'-0"

DOOR SCHEDULE	
1	2-8 x 6-8
2	2-8 x 6-8
3	2-10 x 6'-10
4	2-2 x 6-8
5	2-6 x 6-8
6	6'-0" PLASTER ARCH
7	2-0 x 6-8
8	3-6 x 7-6

WINDOW SCHEDULE		
1	32 x 28	DIVIDED
2	22 x 60	DIVIDED
3	44 x 30	DIVIDED
4	26 x 30	DIVIDED
5	22 x 20	DIVIDED

NOTES

C = CUPBOARD TO EXTEND 2'-0" ABOVE WORK TABLE TO CEILING
C₁ = CUPBOARD. FLOOR TO CEILING. TWO SETS OF DOORS
T = WORK TABLE
ALL TRIM TO BE BIRCH FLOORS. EXCEPT KITCHEN, TO BE RED OAK. KITCHEN FLOOR YELLOW PINE. REAR PORCH MADE OF YELLOW PINE. WALL COMPOSED OF 2x4's LATH, PLASTER, SHEATHING, AND SIDING. ARCH IN LIVING ROOM TO BE PLASTERED PARTITION AROUND SOIL PIPE TO BE 8". USE WOOD LATHS AND THREE COATS OF PLASTER. ALL JOISTS SPACED 16" O.C.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

REDUCED $\frac{1}{4}$' SCALE

An Interesting First Floor Plan with Stairs Facing Entrance

CHAPTER IX

ARRANGEMENT OF STAIRS IN HOUSE PLAN

This study of stair building has covered the problems most likely to be encountered in connection with buildings of the residence type, such as dwellings and small apartment houses. In conclusion the plans of a medium-sized house of Colonial style are presented for study, illustrating the arrangement of the stairs. See Fig. 188.

The traditional Colonial arrangement has been followed in this plan, the living room being on one side of the entrance hall, with the dining room on the opposite side and the stair going straight up facing the front entrance door. As the house is too small to allow for a long straight flight of stairs with no turns, it has been necessary to introduce a half-space, or wide -U turn and this has been placed near the top of the stair so as to give the appearance of a long straight flight as seen from the lower hall. See Fig. 189. As there was not room for two full landings, it was necessary to place winders at the lower turn. The upper turn has a full landing, and advantage is taken of this to provide a door leading from the landing out onto a sun-deck which is "worked in" over the screened porch.

One disadvantage of this arrangement is that there is a long, straight flight of stairs below the winders so that a misstep at the winders would mean a fall down the long flight. It might have been safer to place the full landing at the lower turn and the winders at the upper turn, with the landing below them, but this would have brought the landing too low to give access to the sun-deck. In cases of this kind a choice must be made between two evils, or the plan must be made larger at increased cost.

The starting newel is of a type frequently seen in Colonial style houses. It differs from the one shown in Fig. 134 in that the handrail flattens out very suddenly so that there is practically no wreath. See Fig. 106 also.

The cellar stairs go down underneath the main stairs and are reached from the rear part of the entrance hall and also from the screened porch, the porch door opening onto a landing of the stairs.

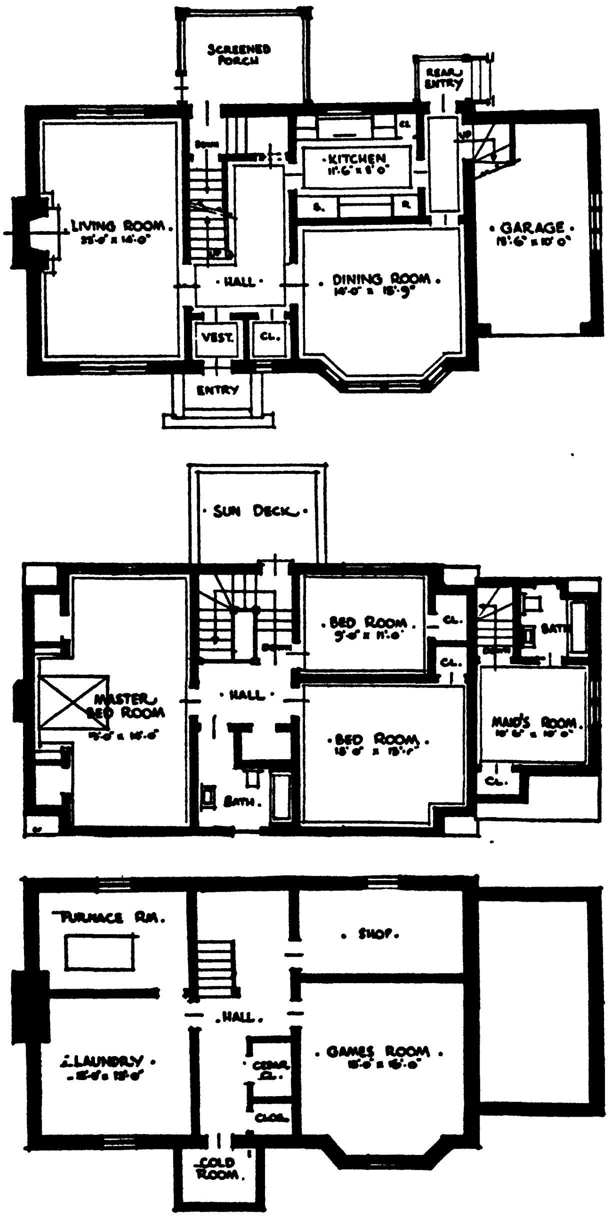


Fig. 188. Plan of House in Colonial Style

Designed by Roderick D. Macdonald, of Ross & Macdonald, Architects, Montreal, Canada

There is a door on the landing at the head of the stairs to the cellar.

This house has no attic, which is in line with modern trends, but over the garage there is a Maid's Room that is reached by means

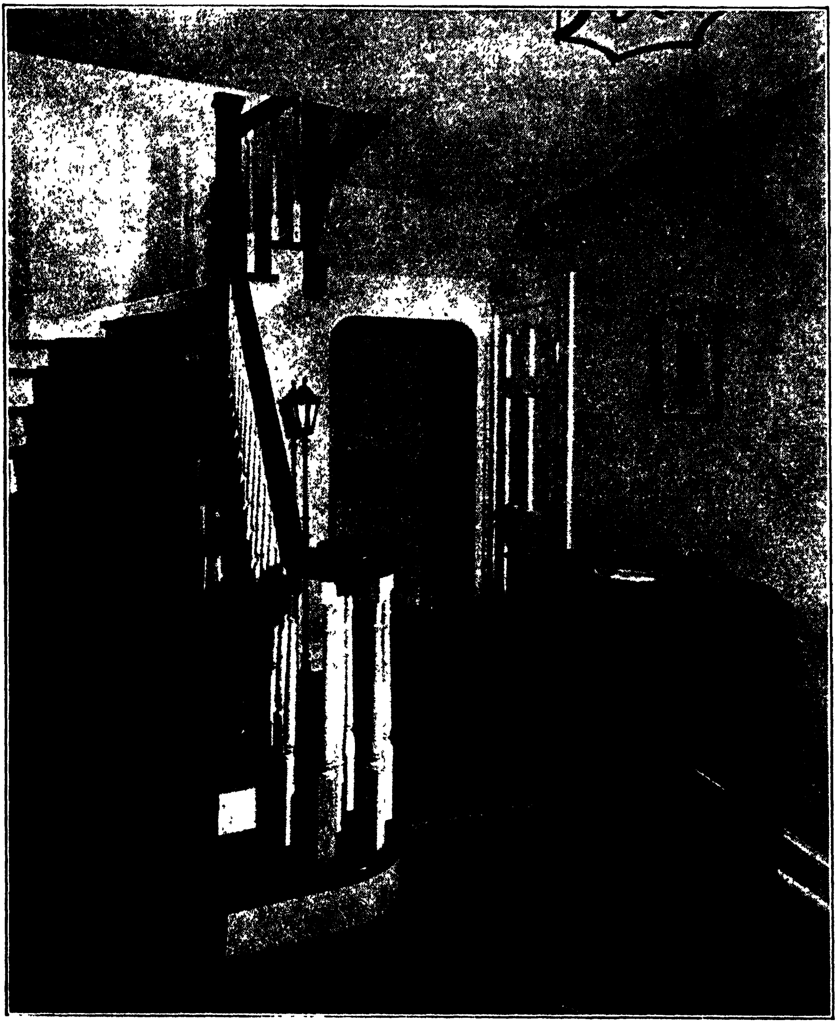


Fig. 189. Colonial Staircase
Courtesy of Associated Screen News, Limited

of a secondary stair from the rear entrance hall. This stair has winders at the bottom and is of the closed type with walls on both sides. The floor of the garage is much lower than floors in first-floor rooms, and it naturally follows that the floor of the Maid's Room is lower than other second-floor rooms. For this reason only seven risers are needed in the stairway which goes up to the Maid's Room from the rear entrance hall.

Near the top of Fig. 189, where the handrail joins onto the upper newel post at the turn of the stairs, is shown an up-casement in the handrail, made necessary on account of the winders which occur at this point.

In the center of Fig. 189 is shown the entrance to an alcove which is located underneath the landing in the upper part of the stair and which gives access to the steps in the rear of the main entrance hall leading to the screened porch. To the right of this alcove entrance is shown the door leading from the main entrance hall to the kitchen.

APPENDIX TO STAIR BUILDING

Fig. 158 shows a diagram illustrating a method for finding the bevels to be applied to the ends of the rough wreath in the case where the tangents are inclined or sloped equally over an obtuse-angled plan. The text tells how to draw out the required bevel but gives no explanation of why the method will find the correct bevel. Some readers may wonder why the method outlined will give the correct bevel and may wish to satisfy themselves that this is so, rather than to have to accept the instruction blindly without understanding the reason for it. As the explanation is rather long and complicated, it seemed best to

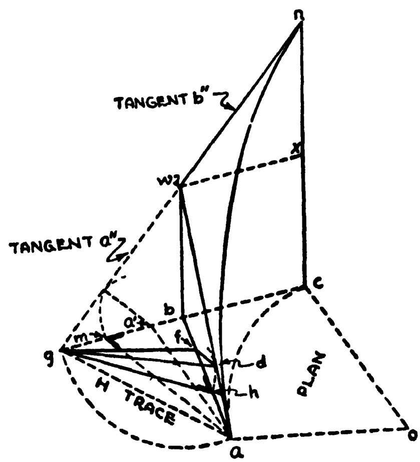


Fig. 190

omit it from the text and to give it in an Appendix for those who wish to study it.

In Fig. 158, the two sloping tangents *a"* and *b"* and the curve of the center line of the face mold (indicated by the curved line in the plan view) all actually lie in a sloping plane (sloping in two directions) which follows the slope of the handrail as it winds upward around the curve at the foot of the stairs, starting at the newel post (at point *a* in the plan view) and ending at the point where the curved handrail joins onto the lower end of the straight part of the sloping handrail above. Fig. 190 shows an isometric view of the center line of this curved sloping handrail from point *a* to point *n*, and of the two tangents to the curve, which are marked *aw* for the lower tangent and *wn* for the upper tangent. A vertical plane passed through the upper sloping tangent *wn* or *b"* is represented by the triangle *gnc*, while a vertical plane passed through the lower sloping tangent *aw* is represented by the triangle *abw*. A horizontal plane passed through the point *a* where the curved sloping handrail intersects the face of the newel post is represented by the trapezoid *gbcoa*. The dotted curve *ac* represents the plan view of the curve of the handrail wreath and the lines *ab* and *bc* represent the plan view of the two tangents to this curve.

The sloping plane of the handrail face mold intersects the horizontal plane in the line *ga* marked *H-Trace*.

The vertical plane *abw* (containing the lower tangent) intersects the vertical plane *gcn* (which contains the upper tangent) in the vertical line *bw*, it intersects the horizontal plane in the plan-tangent-line *ab*, and it intersects the sloping plane of the handrail face mold in the tangent line *aw*. Now the vertical plane *abw* may be swung to the left about the vertical line *bw* as an axis into the vertical plane *gnc* where it will be represented by the triangle *gbw* and the lower sloping tangent *aw* will be represented by the line *gw* marked *Tangent a"*. The plan view of the lower tangent *ab* will be represented by the line *gb* which will be equal to *ab* and, together with the line marked *H-Trace*, then will form an isosceles triangle. The vertical plane *gcn* can be revolved about the horizontal line *gbc* to the left down into the horizontal plane of the plan view to give the diagram shown in Fig. 158.

To find the bevel for the handrail wreath at point *a*, you must pass a plane perpendicular to (or at right angles to) the lower sloping tangent *aw* and find the lines in which this new plane cuts the sloping plane (containing the wreath) and in which it cuts the vertical plane *abw*. This new plane will pass through the point *g*, which is in the sloping plane of the handrail wreath and is at the same time in the horizontal plane *gbcoa* in which the line *ab* also lies. Since this new plane is to be perpendicular to the line *aw*, it necessarily follows that it will be perpendicular to every plane passing through the line *aw*, and therefore the line *gf*, in which the new plane cuts the horizontal plane *gbcoa*, will be at right angles to the line *ab* in which the plane *abw* cuts the horizontal plane. Then it follows that line *gf* can be drawn from point *g* at right angles to line *ab*, locating the point *f*. Also the line *fd* in which the new plane cuts the vertical plane *abw*, passing through line *aw*, will be perpendicular to the line *aw* because if *aw* is perpendicular to the new plane, it is perpendicular to every line in that plane which it touches. Therefore, we can draw *fd* at right angles to line *aw* from point *f* and draw the line *gd*, completing the triangle *fdg* and giving the bevel *fdg* which is the bevel for the lower end of the sloping curved handrail wreath.

Now taking a pair of dividers or compasses with one point placed on point *f* as a center and with distance *fd* as a radius, we can draw an arc tangent to the line *aw* and swing the triangle *fdg* about line *gf* as an axis down into the horizontal plane to give the point *h* and the triangle *fhg* which is the same as triangle *fdg*. Then the angle *fhg* is also the bevel which we are trying to find, and since it is in the horizontal plane of the plan view *gbcoa*, it can be drawn out in plan view and seen in its true dimensions.

Now since the triangle *abg* in the horizontal plane in plan view *gbcoa* is an isosceles triangle with side *ab* equal to side *gb*, a line drawn from point *a* at right angles to the side *gb* (such as line *aa'*) is the same in all respects as the line *gf* drawn through point *g* perpendicular to the side *ab*, and can be substituted for line *gf*. This line is the same as line *aa'* in Fig. 158.

Line *gw* in Fig. 190 is the same as line *aw* and the triangle *gbw* is the same as triangle *abw*, therefore if we take point *a'* as a center and with a pair of compasses draw an arc tangent to line *gw* (or to tangent *a″*) it will give us point *m* on line *gb* which is the same as point *h* on line *ab*. Then triangle *ama′* is the same as triangle *ghf* and the desired bevel for point *a* is also given at *ama′* just the same as at *ghf*. This triangle *ama′* is shown in direct plan view in Fig. 158 where *ama′* is shown to be the bevel required. Since tangents *a″* and *b″* both have the same slope, this bevel is also applicable to the upper end of the handrail wreath at point *n*, Fig. 190.

Fig. 190A is a view of the curve shown in Fig. 190, but from a different position. Fig. 190A shows the line *aw* and *wn* both sloping as in Fig. 190 and

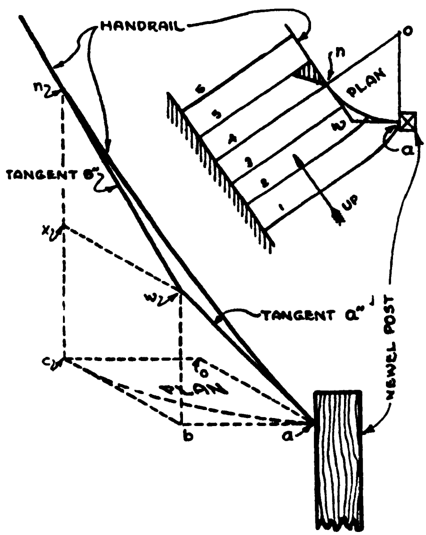


Fig. 190A

shows the curve *an* meeting the face of the newel post at an angle and not level as is the case in Figs. 191 and 195.

In Fig. 190 the handrail wreath does not level out to meet the newel post, but intersects the newel on a slope as shown in Fig. 190A, which is the same curve as is shown in Fig. 190 but viewed from a different position so that line *ab* will appear in its true level position. Here the horizontal, or plan, distance traversed by the tangent *nw* or *b″*, is nearly the width of two treads, say about eighteen inches, while it falls almost the height of two risers, say about 12 inches. Tangent *wa* or *a″* does the same, and this fixes the distances *ab*, *bw*, *wx* and *xn*. They of course depend upon the design of the stair and the handrail as shown by the plan.

In Figs. 159 and 160 is shown a method for finding the bevels for a handrail wreath over an obtuse angle plan where the handrail at the foot of the stairs is ramped out so as to be level at the point where it frames into the side of the newel post (point *a*, Fig. 159 in plan view) and at the same time curves around over the obtuse-angled plan so as to follow the flare of the steps where they widen out at the foot of the stairs. This means that the upper tangent,

b'' in Fig. 159, is sloping, while the bottom tangent, a'', is level; therefore two different bevels are required, one at the bottom of the curved handrail wreath where it joins onto the newel post, and another at the upper end of the wreath where it joins onto the straight sloping part of the handrail (point *n* in Fig. 159).

Figs. 159 and 160, together with the accompanying text, show how to find both bevels, but give no explanation of why the procedure outlined will result in the finding of the correct bevels. The explanation is given in this Appendix.

The statement is made in the text in connection with Fig. 160 that the distance *am* Fig. 160 (which is said to be equal to distance *wm* Fig. 159) placed

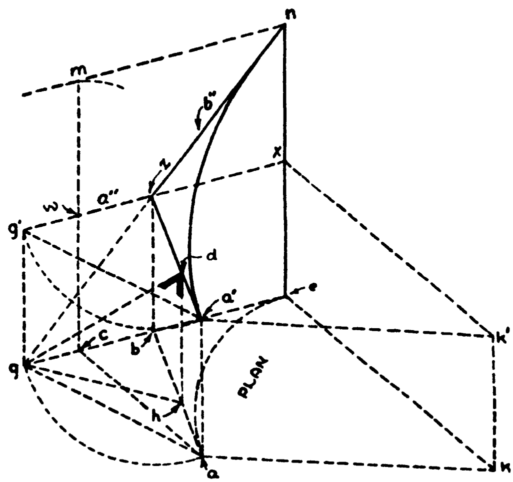


Fig. 191

at right angles to the distance *ac*, Fig. 159, as shown in Fig. 160, will give, at *m* Fig. 160 (after the line *mc* is drawn) the bevel for the lower end of the curved handrail wreath at the newel post, where the wreath is level. Fig. 191 shows in isometric view the curved center line of the face mold of the handrail wreath which is shown in plan view in the lower part of Fig. 159 starting at point *a* and curving to the right. The isometric of this plan view of the curve of the center line of the face mold of the handrail wreath is shown by the dotted curve *ae* in Fig. 191. The isometric of the plan view of the two tangents to this curve shown in Fig. 159 as the lines marked *a* (the lower or level tangent) and *b* (the upper or sloping tangent) is shown in Fig. 191 by the lines *ab* (for the lower tangent) and *be* (for the upper tangent). These two lines *ab* and *be*, Fig. 191, are only the isometric of the plan view of the two tangents to the curve of the handrail. The full curved line *a'n* in Fig. 191 is an actual isometric view of the center line of the face mold of the handrail wreath, the point *a'* representing the point of junction with the newel post (point *a* in Fig. 159) and the point *n* representing the point at the upper end of the curved wreath where it joins onto the straight sloping handrail (point *n* in Fig. 159). Line *zn*, or b'', in Fig. 191 is an isometric view of the upper sloping tangent to the handrail curve (b'' in Fig. 159) and line *a'z* in Fig. 191 is an isometric view of the lower, or level, tangent (a'' in Fig. 159) in its *true* position directly over the plan view *ab*, Fig. 191, of this same tangent. Since tangent *a'z* is a *level* tangent, the line *a'z* must be a level or horizontal line. Therefore line *a'z* must be in a horizontal plane (plane *g'zxk'a'* in Fig. 191) and, since it is tangent to the sloping handrail curve, this line must also be in the sloping plane of the handrail curve, represented by the lines *gzna'* in Fig. 191 and it also lies in the vertical plane *a'zba*.

Now, to find the bevel to use at the lower end of the curved handrail wreath, we must pass another plane through the level tangent *a'z*, or a'', but at *right angles* to it. Because tangent *a'z* is level or horizontal, such a plane must be a vertical plane in order to be at right angles to the level tangent *a'z* and it will intersect the vertical plane *a'zba* in a vertical line such as the line *dh*. Such a vertical plane at right angles to line *a'z* must also be at right angles to the vertical plane *a'zba* in which the line *a'z* lies, and it should pass through point *g* in which the sloping plane *gzna'* intersects the horizontal plane *gcbeka* and the vertical plane *gznec*. Vertical plane *gznec* intersects the horizontal plane *gcbeka* in line *gcbe*, and line *gb* is equal in length to line *be*, therefore *gb* is equal to line *ab*, so that triangle *gba* is an isosceles triangle. If we pass through point *g* the vertical plane *gdh* at right angles to line *a'z*, it will also be at right angles to line *ab* which is parallel to line *a'z* and lies in horizontal plane *gcbeka*. Since line *ab* is at right angles to plane *gdh* it must also be at right angles to line *gh* which lies in vertical plane *gdh* and also in horizontal plane *gcbeka*. Therefore, to locate plane *gdh* at right angles to tangent *a'z*, we can pass a line *gh* through point *g* perpendicular to line *ab* and intersecting line *ab* in point *h*. Then a vertical line *hd* will be in plane *abza'*, and line *gd* will be in the sloping plane of the face mold which is plane *gzna'*, and the desired bevel for the lower end of the curved handrail wreath will be the angle *gdh* shown *in isometric view* in Fig. 191. To get a true view of this bevel, note that, since triangle *gcbha* is an isosceles triangle, line *gh* through point *g* perpendicular to line *ab* is equal in length to line *ac* drawn through point *a* perpendicular to line *gb*. Line *ac* in Fig. 191 is an isometric view of this line, but line *ac* in Fig. 159 is a true plan view of the same line drawn from point *a*, perpendicular to line *b*, and intersecting this line in the point *c*.

From point *h* in Fig. 191, we can draw vertical line *hd* intersecting line *a'z* (and also sloping plane *gzna'*) in the point *d* and we can draw line *gd* lying in the sloping plane *gzna'* to give us the bevel *gdh*. However, note that line *hd* is the same length as line *bz* or line *xe*, and because distance *gb* is the same as distance *be* or *ab*, then *bz* and *xe* and *xn* are all equal, and distance *wm* equals distance *nx* or *bz* or *hd*. Therefore, *ac* can be substituted for *gh*, and *wm* can be substituted for *hd*, and in Fig. 160 *am* (equal to distance *wm* in Fig. 159) can be substituted for *hd* in Fig. 191 and angle *amc* in Fig. 160 is the same as bevel *hdg* in Fig. 191. The relation between Fig. 191 and Fig. 159 will perhaps be clearer if the reader will try to visualize the vertical plane *gen*, Fig. 191, together with all the lines and figures contained in it, as being revolved about the horizontal line *gcbe* to the left down into the same plane with the horizontal plane *gcbeka*. Line *cw*, which shows as a vertical line in Fig. 191, would then appear as an extension of the line *ac*, just as it does in Fig. 159. Line *en* which appears as a vertical line in Fig. 191 would show as an extension of the line *ek*, just as it does in Fig. 159, although in Fig. 159 not all the letters are shown.

In Fig. 159 and Fig. 160 is shown a method for finding the bevel to use at the upper end of the curved handrail wreath over an obtuse-angled plan (that is, at the foot of a stair which widens out at the bottom) when the handrail is ramped out so as to be level at the point where it joins onto the newel post at the foot of the stairs. The statement is made in the text that to find this bevel the distance *ac* in Fig. 159 may be used as the base of a right triangle, such as *wac* in Fig. 160, and that if the distance *ow* in Fig. 159 is used as the altitude of the triangle, as shown at *aw* in Fig. 160, then the angle *awc* in Fig. 160 will be the correct bevel for the upper end of the curved handrail wreath. There

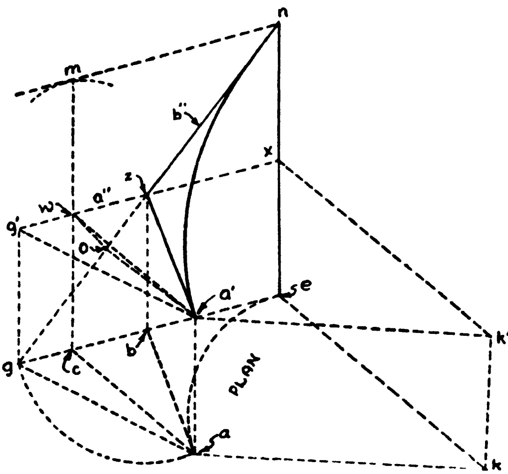


Fig. 192

is in the text no explanation as to why this procedure will give the correct bevel. The explanation is as follows:

Fig. 192 is an isometric view of the curved center line of the face mold of the inclined handrail wreath shown in plan view in Fig. 159 by the curved line starting at point *a*. This figure is the same as Fig. 191 except that it shows the line *wo* and does not show the triangle *gdh*. In Fig. 192, line *zn*, or *b''*, is an isometric view of the upper sloping tangent to the curve of the center line of the face mold of the handrail wreath, and it lies in the sloping plane of the face mold, *gzna'*, and also in the vertical plane *genz*.

To find the correct bevel to be used on the upper end of the handrail wreath (where it joins onto the straight sloping handrail) we must pass another plane at right angles to tangent *b''* and find the lines in which this new plane cuts the vertical plane *genz* and the sloping plane *gzna'*. The angle between these two lines, seen in its true proportions, will give the correct bevel, as explained in connection with previous figures in the chapter on bevels. In Fig. 192 point *a'* and the level (or horizontal) tangent *a'z* lie in the sloping plane containing the tangent *b''* which intersects the vertical plane *genz* in the line *gozn*. If we pass a horizontal plane through the level tangent line *a'z*, it will contain the points *a'* and *z*, and this horizontal plane (*g'a'k'xzw* in Fig. 192) will intersect the vertical plane *genz* in the horizontal line *g'wzx*, and a line in this horizontal plane drawn from point *a'* at right angles to line *g'zx* will intersect line *g'zx* in the point *w*, giving the horizontal line *a'w*. Line *ac* is drawn through point *a*, at right angles to line *gcbe*, and since line *a'a* is vertical, lines *a'w* and *ac* will be equal to each other in length, and line *cw* will be vertical while lines *ac* and *a'w* are both horizontal. Now, to find the desired bevel at the upper end of the handrail wreath, we must pass a plane at right angles to tangent *b"*, that is, at right angles to line *gozn*. Let us pass such a plane through the horizontal line *a'w* sloping *downward* from this line until it cuts the sloping plane of the tangents, *a'zna'*, in the line *oa'*, point *o* being on the sloping line *gzn*. Then angle *woa'* will give the desired bevel if seen in its true proportions.

Since the plane *wa'o* is at right angles to the line *gozn*, the line *ow* is at right angles to the line *gozn* and can be drawn through point *w* perpendicular to this line, and line *ow* will lie in the vertical plane *gen*, in which line *g'wzx* also

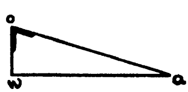


Fig. 193

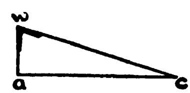


Fig. 194

lies. Since line *a'w* is horizontal, lying in a horizontal plane *g'wzxk'a'*, it will be perpendicular to the vertical plane *gen*, and at right angles to every line in that plane. Line *a'w* will therefore be at right angles to line *wo*, and angle *a'wo* is a right angle, although it does not appear to be so because Fig. 192 shows everything in isometric view. If we then draw line *a'w* (or line *ac*, which is the same length as line *a'w*) and draw at right angles to it (from the point *w*) the line *wo*, and then join the points *o* and *a'* as shown in Fig. 193, we will have at *o* the correct bevel for the upper end of the handrail wreath.

In place of *wa'* of Fig. 193, substitute *ac* which is equal to *wa'*, and in place of *ow* substitute *wa* which we will make equal to *ow* and we will have Fig. 194, with the correct bevel at *w*. Now Fig. 194 is similar to the lower part of Fig. 160 in which the base line *ac* is made equal to the distance *ac* in Fig. 159 and *aw* is made equal to distance *ow*. Fig. 159 gives true views of lines *ac* and *ow* which are shown in isometric view in Fig. 192; therefore Fig. 160 shows the bevel in its true proportions.

The question may be asked: "Why is angle *awc* in Fig. 194 not like angle *awc* in Fig. 160?" The reason is as follows:

Figs. 191 and 192 are isometric views and all distances are shown in isometric, therefore in Figs. 193 and 194 distances *wa'* and *ac* are not shown in their true values. These distances are really like distance *ac* in Fig. 159, and angle *awc* of Fig. 194 is like angle *awc* in Fig. 160; but since these distances are shown in isometric view in Fig. 192 they appear elongated. The true bevel is like angle *awc* in Fig. 160.

In Figs. 191 and 192, curve *a'n* includes the ramp, in the sense that it represents the center line of the face mold of a curved handrail wreath (curved in a horizontal direction and at the same time rising) when the lower end of the handrail has been brought to such a position that a plane perpendicular to the center line of the handrail at this point will be a vertical plane, such as the face of the newel post. The lower end of the wreath will, therefore, be level *at the point where it connects to the newel,* but not at any other point, because as soon as a person's hand, resting on top of the handrail, moves away from the newel post in mounting the stairs, it at once begins to rise slightly with the upward curve of the handrail. Of course the newel post could be moved over somewhat and a short piece of horizontal or level handrail could be inserted between the new position of the newel post and the lower end of the handrail at point *a'* (Fig. 191 or Fig. 192). Since these figures are in isometric, line *a'z* (which is tangent to the curve *a'n* at point *a'*) appears to rise, but it is actually horizontal and parallel to line *ab* which is also horizontal.

Fig. 195 is another isometric view of the same curve that is shown in

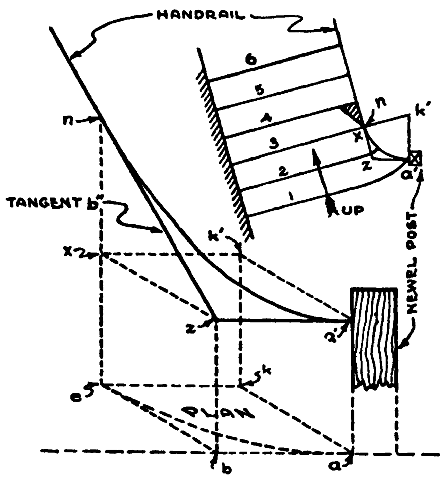


Fig. 195

Fig. 191, but looking at it from a different position, directly facing the handrail curve but looking across the staircase as shown by the small plan. Fig. 195 shows the lines *a'z* and *ab* in their true horizontal position. It also shows the newel post and shows the curve *a'n* brought to a level position at point *a'* where it joins the face *aa'* of the newel post, which, of course, is vertical or plumb. In Fig. 195, if the newel post *aa'* were to be moved to the right a certain distance, say 8 inches, then a level piece of handrail would have to be inserted between point *a'* and the new position of the newel post.

In Fig. 195 the distance from *a* to *a'* is not governed by anything. This distance may be anything to suit the convenience of the draftsman, but in Fig. 191 it must be made equal to distance *nx* so that line *gz* will be a continuation of line *nz*, since *aa'* is equal to *bz* and *gb* is equal to *zx* and *be* and *ab*. Now the line *nz* as shown in Fig. 195, in the plan view of the staircase, is a continuation of the straight sloping part of the handrail and follows the same slope as this handrail. The small plan view of the staircase in Fig. 195 shows that the plan distance from point *x* to point *z* is a little more than the width of one tread, say about 12 inches, while the vertical distance between point *n* and point *z* is the fall of the handrail in traversing the distance *xz* or *nz*. The handrail falls a little more than the height of one riser in going from *n* to *z*, say about nine inches, and this determines the distance *xn* and thereby fixes the distance *aa'* in Fig. 191.

In further explanation of Fig. 159, it may be said that everything above the horizontal line *cb* represents a plane which is actually vertical, but which has been revolved about the line *cb* down into the plane of the page, that is into the same plane as the plan view. A dotted line *wa''* represents the intersection with the above-mentioned vertical plane of a horizontal plane which is passed through the intersection of the ramped handrail with the newel post. The sloping line *b''* represents the intersection with the above-mentioned vertical plane of the sloping plane of the handrail wreath which contains the tangent *b''*. The line *wo* which is drawn from *w* perpendicular to line *b''* (extended) represents the intersection with the above-mentioned vertical plane of a third plane which is passed perpendicular to the sloping tangent *b''*. The line *ac* is equal in length to the line in which this third plane would intersect the horizontal plane passed through the intersection of the ramped handrail wreath with the newel post.

QUESTIONS ON STAIR BUILDING

Chapter I—Types of Stairs and Their Location

1. What is the difference between a close string stair and an open string stair? *Page 2.*

2. What is the distinctive feature of dog-legged or platform stairs? *Page 3.*

3. Describe a double **L** stair. *Page 4.*

4. Give the characteristic features of a **U** stair. *Page 6.*

5. What are some of the important matters to be considered in choosing the location for the stair? *Page 10.*

Chapter II—Stair Construction

6. Describe the process of laying out strings by the use of the steel square. *Page 19.*

7. Describe the method of laying out strings by the use of the pitch-board. *Page 20.*

8. What special care must be exercised in setting up newel posts in the stair framing? *Page 24.*

9. What types of joints are used in joining the risers and treads? *Page 26.*

10. How are the balusters joined to the treads on the stair? *Page 28.*

11. What method of joining is used to connect the housed string to the newel post? *Pages 33-34.*

12. How is the riser of a bull-nose step constructed? *Pages 39-40.*

13. How would you go about laying out the framing for a winding stair? *Page 46.*

14. How is the outside string laid out for a winding stair? *Pages 52-53.*

Chapter III—Laying Out or Designing Stairs

15. What are the three rules frequently used in regard to the proportion of treads and risers? *Page 61.*

16. What is the most desirable height of riser in the main staircase in a home? *Page 62.*

17. What is a good width of tread in a main staircase in a home? *Page 62.*

18. If the height from floor to floor is 8′6″ in a straight run stair and the total run is 11′4½″, what is the height of the riser and the width of the tread? *Page 63.*

19. If there were 15 risers in a stair, how many treads would be used? *Page 64.*

20. What are the recommended minimum clear widths of stairs? *Page 65.*

21. What is the average headroom allowed from the top of the tread of the lower stair to the under side of the stair above? *Page 67.*

22. When a stair is designed to allow two people to pass, how wide must it be? *Page 68.*

23. What is the benefit of a rather wide landing and a wide upper hall when a somewhat narrow stair is used? *Page 70.*

Chapter IV—Building the Stairs

24. How is a story rod used to lay out the actual dimensions of the risers and treads in a stair? *Pages 73-74.*

25. What parts of the stair, as distinguished from the framing, are called stair finish? *Page 76.*

26. When the handrail passes over the top of the newel post, how is the end of the rail finished? *Page 79.*

27. What is the name given to the part of the handrail which is used in connection with winders? *Page 81.*

28. The triangle formed by the pitch-board is made by the lines of intersection of three planes with a fourth plane. Name these planes. *Page 84.*

29. To see the true length of a line or an object, how must you look at it? *Page 86.*

30. What is the name given to the true view or pattern of the top surface of the handrail? *Page 89.*

Chapter V—Curved Handrails

31. Where are goose-necks and curved handrails used? *Page 91.*

32. When a handrail is curved in a vertical plane only, what is the name given to the curved section? *Page 91.*

33. What is the advantage of widening out the two bottom steps in a stair? *Page 93.*

34. What is the name given to a part of a handrail which is curved in both the vertical and horizontal planes? *Page 93.*

35. What is the name given to the winders in the geometrical stair shown in Fig. 67, page 46? *Page 94.*

36. What are tangents? *Page 95.*

37. How are tangents used in connection with the laying out of a handrail? *Page 95.*

38. Describe briefly the tangent system of handrailing? *Page 96.*

39. What does the part of Fig. 115 shown in dotted lines represent? *Page 99.*

40. In Fig. 114A, page 99, what does the line marked tangent *m* represent?

41. In Fig. 114B, page 99, what does the curve *a'h* represent? *Page 100.*

42. In Fig. 116, page 101, what does the curved line shown in the section represent? *Page 100.*

43. In Fig. 119 it will be noted that the two tangents both cross risers in the plan view. What does this indicate? *Page 103.*

44. In Fig. 120, page 103, what does the curved line represent? *Page 104.*

45. In Fig. 122A on page 106, what lines indicate the plane *dcoe* in the vertical plane? *Page 106.*

46. The curved line *c''n* in Fig. 122A, page 106, represents what line of Fig. 121?

47. In Fig. 124, how are the tangents *wh* and *wn* obtained? What is the object of getting these two tangents drawn out to their true length showing the true angle between them? *Page 110.*

48. In Fig. 125, how are the points *1, 2, 3, 4,* and *5* shown on the center of the wreath obtained? *Page 110.*

49. In Fig. 127, what determines the height of the line *m'n*? *Page 115.*

50. In Fig. 128, what determines the inclination of tangent *a″*? *Page 117.*
51. In Fig. 129, the joint at *c″* is a butt joint. Why? *Page 119.*
52. In Fig. 132, what line represents the true length of tangent *c″*? *Page 123.*
53. Why is a handrail ramped where it meets the newel post? *Page 124.*
54. In Fig. 135, how was the pitch of the stairs found? *Page 127.*

Chapter VI—Bevels

55. Fig. 138 shows that, throughout its entire length, the axis of the mold is at right angles to the rough block. Why is this? *Page 131.*

56. In Fig. 142, why must the axis of the handrail molding be vertical at the upper end of the handrail wreath? *Pages 132-133.*

57. Why is the wreath in Fig. 143 said to be twisted? *Page 134.*

58. How is the bevel used to mark out the proper angle for handrail cross sections? *Page 134.*

59. In a case where the sloping plane in which the handrail wreath lies is inclined in one direction only, and one of the tangents to the curve of the center line of the face mold is horizontal, how is the required bevel found? *Page 135.*

60. What are trammel points and how are they used? *Page 138.*

61. In Fig. 151, how is the line of the sloping tangent laid out? *Page 139.*

62. The top and bottom surfaces of a rough handrail are inclined or sloped in two directions. How many bevels are required? *Page 140.*

63. How is the bevel for the upper end of the handrail wreath found in Fig. 154? *Page 145.*

64. Where is the bevel used that is shown at *dhg* in Fig. 155? *Page 148.*

65. How would you find the bevels for a wreath when the upper tangent slopes less than the lower tangent? *Page 149.*

66. How many bevels are required when two equally inclined tangents are over an obtuse-angle plan? *Page 149.*

67. How many bevels are required when the upper tangent is shown to incline and the bottom tangent is shown to be level over an acute-angle plan? *Page 151.*

Chapter VII—Laying Out Handrails and Face Molds

68. How is the width of a face mold fixed at each end? *Page 156.*

69. What is the angle which the vertical axis of the handrail section makes with the plane of the top surface of the rough block called? *Page 156.*

70. Describe the pin method for laying out curves of face molds. *Pages 155-159.*

71. Describe the simple method of laying out curves of face molds. *Page 160.*

72. Why will the molding of some handrail wreaths have the appearance of being twisted? *Page 161.*

73. In Fig. 168, how was the true view of the under side of the face mold found? *Page 163.*

Chapter VIII—How to Lay Out Stairs to Simplify Handrail Problems

74. In what way may a great deal of labor and material be saved in wreath construction for geometrical stairways? *Page 165.*

75. What is the simplest and easiest arrangement for the risers around a wellhole in stairways which have an intermediate landing at the end of the wellhole? *Page 166.*

76. In Fig. 171, what fixes the width of the landing and the position of all the steps with reference to the curved end of the wellhole? *Page 166.*

77. Explain how to find the height of a handrail above the landing for the stairs shown in Fig. 170. *Page 167.*

78. In Fig. 174, the risers at *a* are placed at a distance from *c* equal to a full tread. Explain why this is not a desirable arrangement. *Page 171.*

79. In Fig. 174, the risers at *a* are placed at a distance from *c* equal to a full tread. In such a case, how may undesirable consequences be avoided? *Page 171.*

80. In Fig. 175, there is required a piece of handrail curved in a horizontal plane as shown at *bc* in the plan view. What would you call this piece of handrail and which of the ones illustrated in Fig. 176 would you use? *Page 174.*

81. In Fig. 176, which of the illustrations is an up-easing and where is such a piece used? *Page 174.*

82. What type of a wreath is required at the landing at the top of a flight of stairs when the handrail of the flight intersects with a level landing rail? *Page 175.*

83. Fig. 182 shows a quarter turn between two flights. What is the correct method for placing the risers in and around the curve? *Page 177.*

Chapter IX—Arrangement of Stairs in House Plan

84. In Fig. 188 why was it necessary to use a half-space or U turn? *Page 181.*

85. Note the steps in Fig. 188 leading to the maid's room. What type of stair is this? *Page 183.*

86. Why is it that the stair for the maid's room has fewer risers and treads than the main stairway? *Page 184.*

INDEX