17 The Construction of Stairs and Handrails

Straight flights, dog-legged stairs, and open-newel stairs have already been dealt with in the companion book, *Practical Carpentry and Joinery*. The types to be described in this chapter are known as geometrical stairs. These do not contain newel posts and therefore have to be constructed with continuous strings and handrails.

Details of a geometrical staircase. Let us first consider the general layout of a geometrical stair. Fig. 1 is the plan of such a stair, and comprises two straight flights of five steps in each, these flights being connected by three winders where the stairs change direction. The first step in a traditional geometrical stair is usually shaped like the one shown on the plan which is called a curtail step. The shaped end generally follows the curve of the handrail scroll which is immediately above it.

A variation to the curtail step is the commode step, the outline of which can be seen in broken line. This is constructed in the same way as the curtail step but it also has a curved riser which goes across the full width of the stairs. The plan of the stairs is only one of many layouts that it is possible to get with geometrical staircases. For instance, the two straight flights can be connected with a quarter-space landing instead of the winders; the turn of the stairs can be 180°, not 90° as shown; also the two parallel flights can be connected by a half-space landing; or a half-turn of winders, or even a quarter-space landing and a quarter-turn of winders.

String details. The wall strings are constructed similarly to those for dog-legged and open-newel stairs, but the outer strings are often cut to the outline of the steps, as seen in Figs. 2 and 3. These cut strings, as they are called, are prepared so that the treads actually rest on the top horizontal surface of the step outline, and the risers are

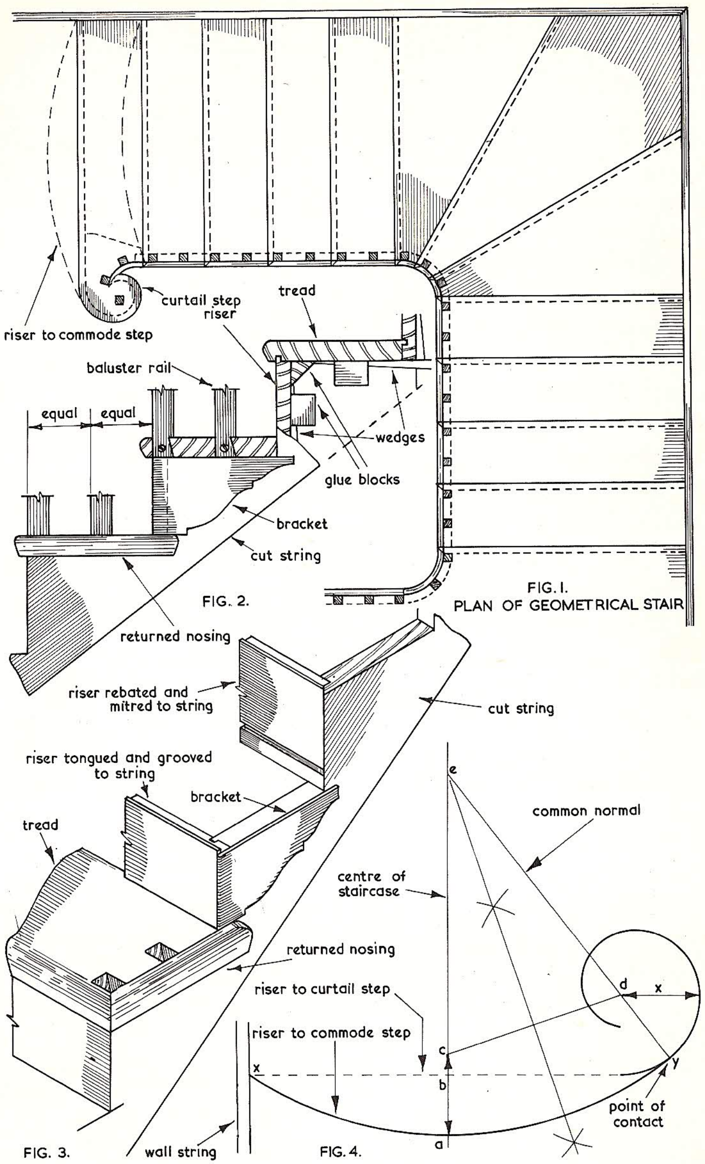


FIG. 1. PLAN OF GEOMETRICAL STAIR

FIG. 2.

FIG. 3.

FIG. 4.

either mitred or tongued-and-grooved to the front vertical edge, see Fig. 3. If the risers are tongued-and-grooved to the string, the end grain of the riser is concealed with a shaped bracket. This is a thin piece of solid timber or plywood, glued and pinned to the surface of the string. No bracket is required if the riser is mitred to the string.

The top step in Fig. 2 shows details of how the treads and risers are tongued-and-grooved together. These details are slightly different from those for steps in closed or uncut strings, being more practical for the cut-string type of stair.

The baluster rails are dovetailed to the ends of the treads and glued and screwed into position, the joints being hidden by the return nosing which is mitred to the front nosing of each step, see Fig. 3. The method used for correct positioning of the baluster rails is shown in Fig. 2. As many glue blocks as necessary should be used for strengthening the steps.

Up to now we have not mentioned the portions of the strings which involve the change of direction, neither have we dealt with the shaped steps. Let us consider the curved portion of the strings first.

Curved strings. Fig. 11 deals with the turn in the staircase at the top of the first flight, but before we consider this problem we should first take a simpler example. Fig. 9 shows how these curved portions of the strings are constructed. We have to make a drum or former on which the timber can be bent to the required shape. These curved portions of the strings are built up to any required thickness with veneers from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. thick. The first of the veneers to go on to the drum should have the marking-out lines transferred from the rod to its inside surface, see Fig. 8. The veneer is then carefully positioned, bent round the drum, and fixed in position with clamps or G cramps, Fig. 9. Other veneers are added to the first, say three or four at a time, the surface of every veneer being covered with a cold-water glue such as casein or some suitable synthetic resin glue. Each veneer must be kept in close contact with the surfaces of the adjacent veneers, additional clamps being used as necessary for this purpose. When the glue has hardened the built-up string can be removed from the drum and, by following the lines which were placed on the first veneer to be placed on the drum, it can be shaped and prepared as seen in Fig. 10.

Fig. 5 shows how a continuous string for a staircase of two flights

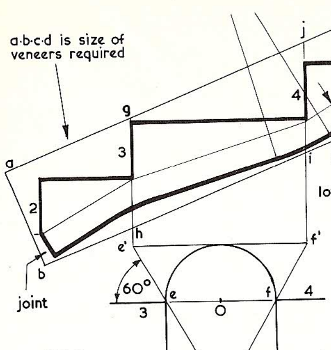
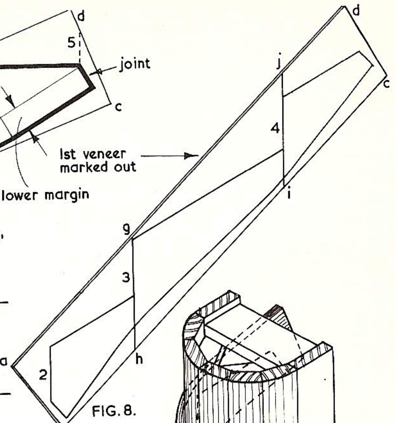


FIG. 5.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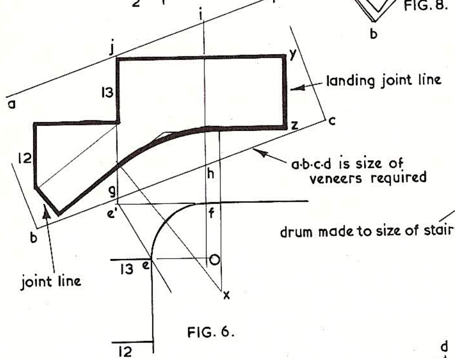


FIG. 6.

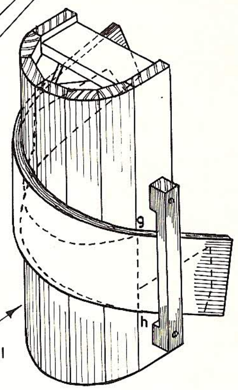


FIG 9 BUILDING UP THE CURVED STRING

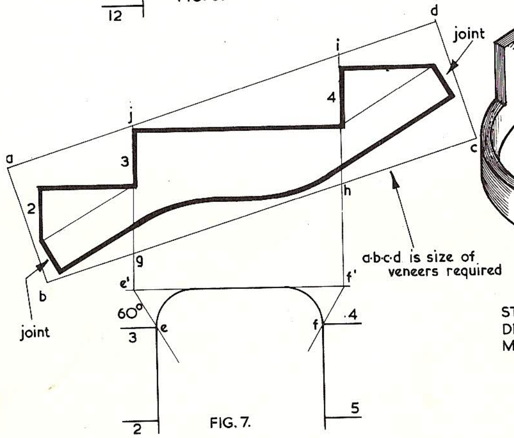


FIG. 7.

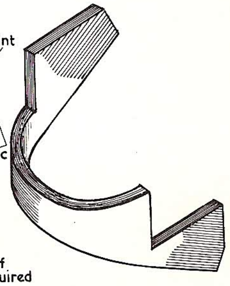


FIG. 10.
STRING REMOVED FROM DRUM AND SHAPED TO MARKS ON FIRST VENEER

connected by a half-space landing should be set out. The lower part of the drawing shows the plan of the stairs. Risers 2 and 3 are the top steps of the lower flight, and risers 4 and 5 the lower risers of the top flight. The space between risers 3 and 4 is the half-space landing.

Preparing a stretch-out. To obtain what is called the stretch-out of the steps, two 60° lines should be drawn, one through each end of the diameter e–f to intersect the horizontal line just touching the top of the curve in e′ and f′. The distance e′–f′ is the horizontal distance from e round to f seen in the plan. Project e′ and f′ upwards vertically so that the stretch-out of the steps can be constructed as shown. The only dimensions required to draw the stretch-out are the 'going' and the 'rise' of each step.

Having drawn the outline of the steps in the stretch-out, straight lines connecting the lower ends of the risers should be drawn and the distance known as the lower margin marked parallel to these lines. This lower margin can be any dimension, and depends on the construction of the stairs. If, for instance, the stairs are fairly wide, say 4 ft. 6 in. to 5 ft., it may be necessary to support the centres of the steps with a carriage and a series of brackets, see Fig. 14a.

As it is necessary to add a soffit to the underneath surface of the staircase it is also essential to have the lower margin wide enough to come below the lower edge of the carriage pieces so that the soffit is supported.

Joints. It will be noticed that the joint at each end of the stretch-out is one step behind the end of the curved portion. For instance, at the lower end of the marking out it can be seen that the joint is immediately below riser number 2, but the string does not begin to turn until it gets to riser number 3. At the top end the same thing occurs; the curve of the string stops at riser number 4, but the joint is immediately below riser number 5. These joints are where the section of the curved string is joined to the straight strings of the lower and upper flights.

The type of joint used is the counter cramp, see Fig. 14. Before placing the veneer which has been set out round the drum, it must be ascertained that the guide lines g–h and i–j are on the veneer. These will assist in placing the veneer on the drum in the correct position. If they coincide with the ends of the curved portion of the drum and are in the vertical direction, it is fairly safe to assume that the 'rise' or position of the veneer is correct.

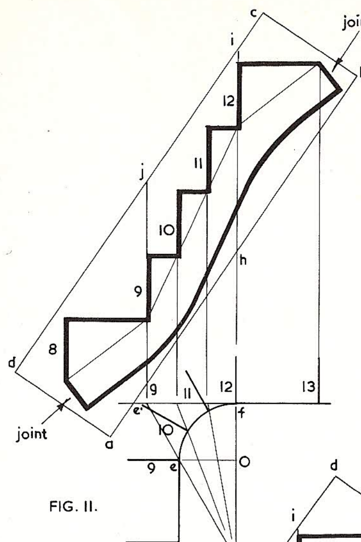
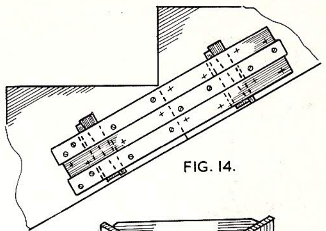


FIG. 11.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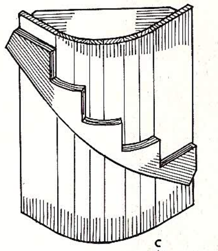


FIG. 15.

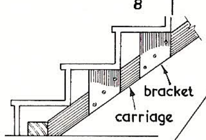


FIG. 14a.

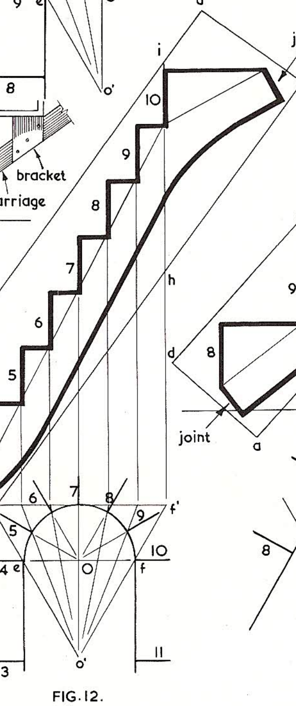


FIG. 12.

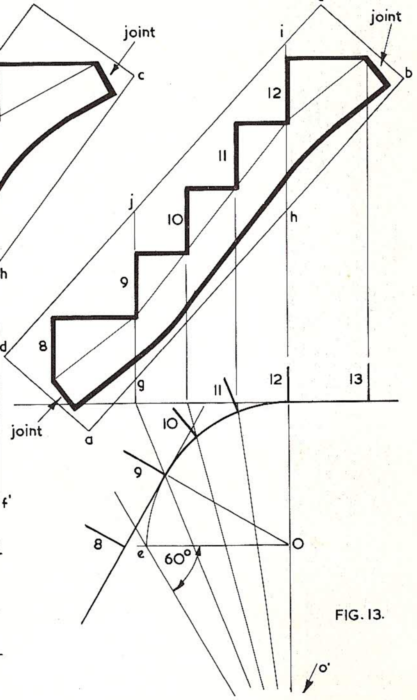


FIG. 13.

Fig. 10 shows what the curved portion of string will look like when it has been removed from the drum and shaped.

Fig. 6 is a plan of a straight flight rising to a landing, riser number 13 being the last one on the stair. As the turn in this example is of 90°, a 60° line through point e to intersect the horizontal line in e′ will give the distance round the curve from e to f, the developed distance being e′–f. Remember that the curved portion of string this time is jointed to the front apron piece which forms the face of the landing timbers. Therefore from riser 13 on the development, the direction of the marking out will be horizontal, following the line of the landing. The distance between points y and z will be equal to the depth of the apron piece along the front of the landing.

Fig. 7 is an example similar to that in Fig. 5, two straight flights connected by a half-space landing. The distance e′–f′ is equal to the distance e–f on the plan. Remember, lines h–i and g–j must be placed on the first veneer in every case.

Quarter space of winders. We now come to a turn in a stair similar to that in the staircase in Fig. 1. Two straight flights are connected by a quarter-space of winders (see Fig. 11). The distance e–f is developed in the usual way by drawing a 60 degrees line through e, the dimension e′–f being the distance round the turn from e to f. As we also require the positions of risers 10 and 11 on the stretch-out, the 60° line should be extended downwards to meet the vertical line from o in o′. Lines from o′ should be drawn through the ends of risers 10 and 11 to give their positions on line e′–f. It should be fairly clear what should be done from this point to complete the marking out. Fig. 15 shows the completed portion of the string put back on the drum until it is required.

Half-space of winders. Fig. 12 shows the setting out for two flights connected by a half-space of winders, and the drawings should be clear enough to follow if the foregoing notes have been memorised. Fig. 13, however, shows two flights connected by a one-third space of winders, or in other words, two flights connected by winders giving the stairs a 60° turn.

The plan of the stairs should be constructed, and the curved portion can, temporarily, be changed into a 90° turn as shown. A 60° line from e downwards to meet a vertical line from o to give point o′, and

lines from o′ through the ends of risers 9, 10 and 11 will give the positions of these risers in the stretch-out.

Shaped bottom step. We should now turn our attention to the shaped steps at the bottom of the staircase. Consider the curtailed step first, Fig. 20. It is necessary to know the shape of the scroll which is situated immediately above the shaped end of the step. The outline of this is first constructed (see Fig. 11 Chapter 19), and the setting out of the shaped end of the curtail step superimposed over the scroll lines, making the nosing line of the step follow the outside edge of the scroll. As can be seen from the drawings, a block is first made similar to the shape taken from the setting out (Figs. 20 and 22). This can be built up from several pieces of timber with the grain going in opposite directions like a piece of plywood. If a bandsaw is available the shape of the block is best cut on this.

A modern staircase with a centre laminated string. The treads are cantilevered on each side of the string and are fixed with purpose made brackets. The string is approximately 28 ft. long, 18 inches wide and 15 inches deep, the laminations are of 1 inch Douglas Fir and were glued together with 'casco' casein glue M1562.
Elliott, White, Reading.

The block is fixed to the end of the string by means of a tongued-and-grooved joint, and is glued and screwed. Recesses should be made in the block to receive a pair of folding wedges near the centre of the block. These are used for fixing the two veneers which meet at that point; and another recess is needed for receiving the riser less the thickness of the veneer at the front of the block.

The short veneer should first be fixed by gluing to the block, and this can be accomplished by the use of a former block and G cramps. The former block is cut to fit up against the veneer when it is in position, and the G cramps will hold the veneer tight up against the block until the glue has set.

The longer veneer is obtained by reducing one end of the first riser to between $\frac{1}{16}$ in. and $\frac{1}{8}$ in., taking care to keep the thickness uniform throughout its length. When the G cramps and block have been removed the second and longer veneer can, if necessary, be steamed or soaked in hot water to soften the fibres. The veneer and block surfaces are glued, and the end of the veneer entered into the recess for the folding wedges near the centre of the block. The wedges should then be glued and driven home, care being taken to see that the veneer is positioned correctly so that its edges will run parallel to the block when it is wrapped around into its final position.

To enable the surfaces of the block and veneer to come in to close contact with one another, folding wedges are glued and inserted between the shoulder at the end of the veneered portion and the block and carefully driven home. Screws can be used for keeping the remainder of the riser up against the block, as seen to the left of Fig. 20. The tread to the shaped step is prepared to the shape of the outline of the scroll. This is the nosing line indicated on the plan, Fig. 20.

Commode step. If this is to be constructed, the manner described for the curtail step can be followed with slight variations. The block requires two formers, one at the top and one at the bottom, recessed into it so as to form the curved riser which goes right across the width of the stairs, see Fig. 21. Saw kerfs are used in bending the thicker portion of the riser. Some difficulty, however, may be found in setting out the shape of the step, see Fig. 4. Let a–e be the centre line of the staircase, a–b the amount the curved riser is in front of its position if it were a curtail step, and a–c the radius of the last curve used when setting out the scroll. This is equal to d–y, Fig. 4. Join c and d and then

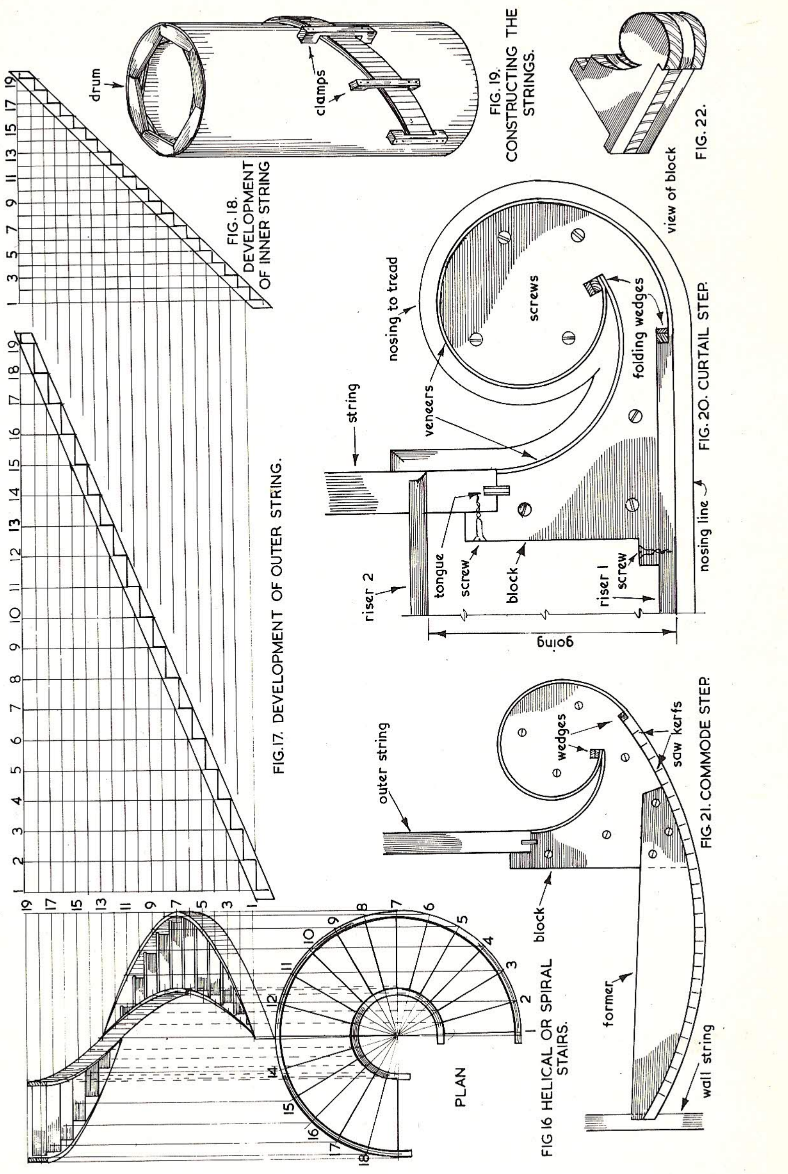


FIG 16 HELICAL OR SPIRAL STAIRS.

FIG.17. DEVELOPMENT OF OUTER STRING.

FIG. 18. DEVELOPMENT OF INNER STRING

FIG. 19. CONSTRUCTING THE STRINGS.

FIG. 20. CURTAIL STEP.

FIG. 21. COMMODE STEP.

FIG. 22.

bisect this line to give e on the centre line of the stair. Use centre e for drawing the curve y–a–x.

Spiral stairs. We now come to a different type of geometrical stair, namely, the spiral stair or, more correctly, the helical stair. In the plan, Fig. 16, the stair appears to be circular, and the elevation shows that it is similar to the thread of a screw or bolt. The strings to a helical staircase are constructed in the same way as for the type of staircase already dealt with. They are built up to any required thickness by using a number of veneers. In a staircase such as that in Fig. 16, the thickness of the veneers could be as much as $\frac{1}{4}$ in. A drum, similar to that shown in Fig. 19, has to be made to the required dimensions, and veneers placed round it and clamped in position until the glue has set. The first veneer to be placed on the drum in the case of the outer or longer string, and the last veneer in the case of the inner or smaller string, must have the marking-out lines placed on them, as for the continuous string of the other type of geometrical stair.

It should be realized that to set out the strings to a helical stair, it is not necessary to draw the elevation of the staircase as shown in Fig. 16. This drawing has been included to illustrate the type of stair we are dealing with. All that is needed is the plan of the stair and knowledge of the rise of each step.

String development. To develop the outside or larger string to the stair, first draw the plan and number the risers 1, 2, 3, etc. On a horizontal line mark off the distances 1–2, 2–3, 3–4, etc. These dimensions can be taken from the plan. Remember that it is the first veneer of this string which must have the marking out placed on it, so the distances 1–2, 2–3, etc. are taken from the inside edge or the concave edge of the string. Mark these distances 1–19 on the horizontal line, Fig. 17, and drop vertical lines from all these points to intersect with horizontal lines brought over from the vertical line, giving the heights of all the risers to the stair.

This vertical line is similar to a storey rod and can be seen to the left of Fig. 17. Draw in the outline of the steps obtained and then mark in the top and bottom edges of the string to any convenient size. As can be seen, the string is a straight piece of timber, and has only to be placed round the drum at the correct rake or angle to produce the correct curvature. In the workshop the setting out of the string would be done on the surface of the drum and not on a large flat surface

because this would probably not be practicable. The foregoing description is included to enable readers to understand the geometry involved.

The inner string is made in the same way. Another drum, to the required dimensions, is made, and the veneers to form the small string are cramped round it as for the larger string. As it is the last veneer which must have the marking out placed on its surface, the distances 1–2–3 etc. on the horizontal line have to be taken from the plan of the small string, Fig. 16, and on the edge nearest the outside or large string. This veneer will be clamped on to the drum last of all, and straight on to the top of the others already in position. Remember to place the veneers round the drums at the correct rake. It is quite simple to work out how high the top edge of the strings have to rise in passing round the drum the required distance. For instance, the strings in Fig. 16 have to travel upwards a distance of 19 risers in passing round the drum three-quarters of a turn. Remember, also, that the top edges of all the veneers have to lie in a horizontal plane when tested radially.

The steps to a helical stair can be of the traditional kind or can be of the open-riser type, which means that treads only are to be used. The strings can be recessed to take the ends of the treads or treads and risers in the usual way. Some modern staircases constructed in the helical style have a central string and the treads fixed to the string by means of wooden or purpose-made metal brackets. Sometimes these strings are as much as 18 in. to 2 ft. in depth. They are built up with $\frac{1}{2}$ in. thick veneers, three or four being placed round the drum at a time, these being left for twenty-four hours when another four are added, and so on until the required thickness has been reached.

Handrailing. We now come to the problem of handrailing. As no newels are included in geometrical stairs, the handrails have to be continuous like the strings. To form the curved portion of handrail at the change of direction in the traditional way of handrailing, however, demands a greater knowledge of geometry, especially in handrailing involving two bevels.

Single-bevel work. The first two examples are single-bevel work and are not very difficult when compared with two-bevel work. When we consider all the other examples in this chapter, however, the reader will have to turn to Chapter 19 and learn how to develop oblique planes if he wishes to understand what is happening in this part of the work on handrailing. Let us consider the example in Fig. 23. At the bottom of the illustration is shown the plan of a staircase at the top of a straight flight of stairs leading to a landing. The handrail at this point is also shown. Above this drawing is the elevation of the last two steps in the flight which will, of course, give the pitch of the stairs. Notice that the curved portion of handrail in the plan is placed centrally over the quadrilateral a–b–c–d. This quadrilateral is the plan of a square prism with its top surface inclined at an angle, in this case equal to the pitch of the stairs (Fig. 26).

Preparing templets: To develop the shape of the templet required to make the curved part of the handrail, it is first necessary to develop the shape of the top surface of the prism, and from that develop the shape of the templet. Proceed as follows. Draw the plan of the handrail and the elevation of the top steps. Place in position the plan of the square prism so that sides b–c and c–d are in line with the centre lines of the handrail. Draw the pitch line of the stairs, and project up to the pitch line the edges a–d and b–c of the prism to give a and b on the pitch line. Project these points over at right angles and make a–d and b–c in line. Then a–b–c–d in the development equal to a–d and b–c in the plan. Then a–b–c–d in the development is the true shape of the top surface of the prism.

Divide the width of the plan of the prism into any number of parts and project these points up to the pitch line, and from here over to the c–d edge of the development. Make the distances a–a′, a–a′′, 1–1′, 1–1′′, etc. equal to those in the plan. Draw freehand curves through these points to obtain the shape of the templets required. Add two straight sections, say 2 in. long, on each end of the curved templet to complete its shape.

Two templets this shape are required for the wreath (this is what the curved portion of the handrail is called), and these can be cut from, say, $\frac{1}{4}$ in. plywood, see Fig. 25a. The thickness of the material required for the wreath is found by drawing a horizontal line to represent the top edge of the material (25c). Draw a line at any point at the same angle as the bevel shown in the elevation, Fig. 23, and from this angle construct a rectangle equal to the size of the handrail. Draw another horizontal line through the bottom edge of the handrail, and the distance between the two horizontal lines is the minimum thickness of timber required for the wreath.

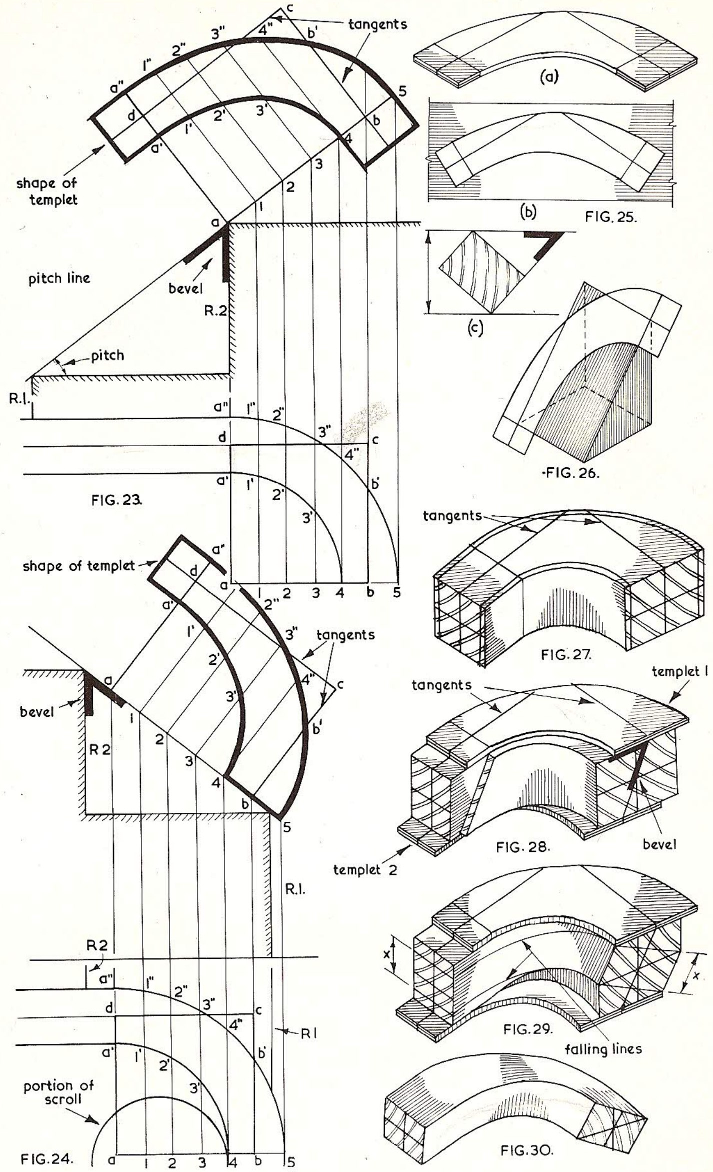


FIG. 23. FIG. 24. FIG. 25. FIG. 26. FIG. 27. FIG. 28. FIG. 29. FIG. 30.

Fig. 24 shows how the templet for the wreathed portion of a scroll is developed. In this case, no straight portion is required where the wreath joins the flat portion of the scroll. Notice that the tangent lines are placed on the templets. These assist in positioning the last named correctly on the timber to be shaped.

Fig. 25a shows a templet prepared and 25b how it should be placed on the plank from which the wreath is to be produced. If placed in this way it eliminates as much as possible the 'short grain' in the material. Having marked the shape of the templet on the plank its shape is cut out with the bow-saw or, better still, on the bandsaw, cutting about $\frac{1}{2}$ in. away from the lines around the curves, and about $\frac{1}{32}$ in. away from the ends. Afterwards, the ends can be cleaned up, perfectly square, with a smoothing plane.

Fig. 27 shows the wreathed portion for the scroll prepared ready for shaping. Note that the tangent lines have been placed on the timber, and these have been squared down the ends. Other lines have been squared over each end and exactly half way down the thickness of the material.

Marking the timber. The templets can now be placed on the timber, and care must be taken to position them correctly. First a sliding bevel must be set to the bevel seen in the elevation and a line marked on the wider end of the timber, allowing it to pass through the intersection of the lines squared across the end, see Fig. 28. The templets are placed on the material, one on each surface, so that the tangent lines are immediately over the ends of the bevel at one end and the tangent line on the wreath at the other end.

The next task is to remove all the timber on the wreathed portion which is outside the edges of the templets, Fig. 29. When this has been done it should be possible to place a straight-edge across the edges of the templets and have the surface of the straight-edge in contact with the shaped surface of the wreath.

The next step is to remove both templets and mark the section of the handrail on the ends of the wreath (Fig. 29). The top and bottom edges of the material are then prepared as in Fig. 30. This is done by carefully placing the falling lines on the wreathed portion in such a way as to avoid any irregularities and to assure a good sweeping curve to the handrail when completed, see Fig. 29. At all times the top and bottom edges of the wreath should be at right angles to the side surfaces.

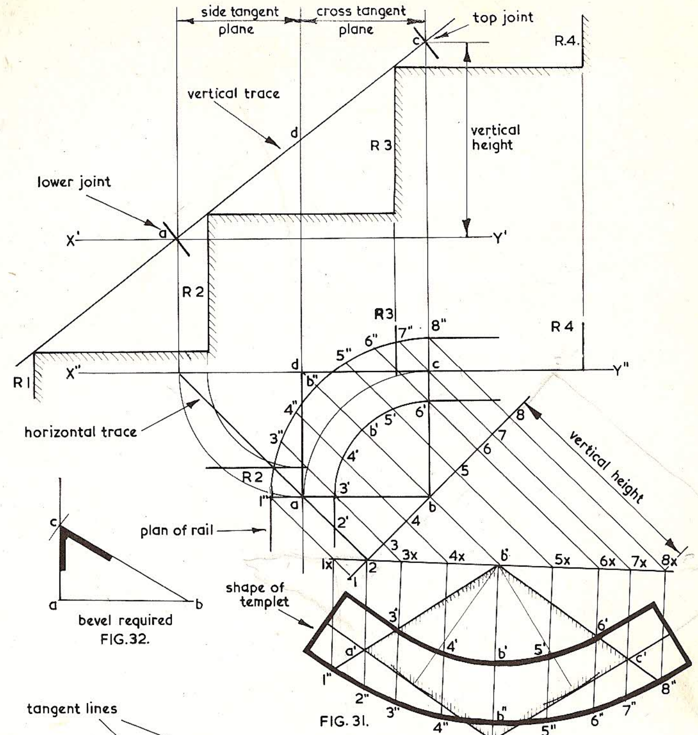


FIG.32.
FIG. 31.

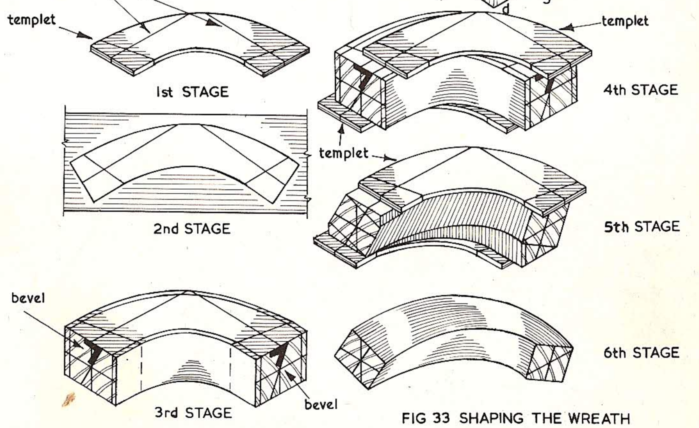


FIG 33 SHAPING THE WREATH

When the wreathed portion has been prepared in its square form it is moulded and then is ready to be fitted to the straight sections of handrails by using the handrail bolt and dowelled joints.

Two-bevel work. We now come to two-bevel work in handrailing in which, as the term implies, two bevels are applied to the wreath, one at each end. It is necessary to emphasize that a knowledge of the development of oblique planes, Chapter 19, is required to follow this part of the chapter on handrailing.

Let Fig. 31 be the plan of a turn in a staircase, this being two straight flights connected by a quarter-space landing, the space between risers 2 and 3 being that occupied by the landing. Since two-bevel work is based on a prism, as in one-bevel handrailing, it is necessary to superimpose the plan of the turn on to the plan of a prism. As the two flights are at right angles to one another, the prism is square.

Let a–b–c–d be the plan of the square prism. Make the sides of the prism equal the radius of the turn to the centre line of the handrail. The centre line of the handrail travels from a round to c.

The next step is to draw the stretch-out of the steps around the turn, so with centre d and radii d–R2 and d–a in turn, project these points round to the x′′–y′′ line. The vertical line from R2 will give the position of riser 2 in the stretch-out, and vertical lines from R3 and R4 will give the positions of these risers. The stretch-out can now be drawn, making the rise of each step suit the requirements of the stairs. In Fig. 31 the distance R2–d added to the distance d–R3 are equal to the width of one tread. This has been done deliberately in this first two-bevel example to simplify the problem, as will be seen later in other examples. The falling line can be drawn through the nosings giving the positions of the joints at the edges of the side- and cross-tangent planes. These are obtained by drawing vertical lines from c, d and the point where the curve projected round from a intersects the x′′–y′′ line. The falling line, as it passes over the side-tangent plane, gives the vertical trace of the top surface of the prism, this being the surface we have to develop to obtain the shapes of the templets. The x′–y′ line is drawn through the point where the falling line intersects with the edge of the side tangent plane.

Reference should now be made to the oblique planes in Chapter 19 to see how the surface a–b–c–d is developed, Fig. 58. Having obtained this shape, a′–b′–c′–d′, one can proceed to develop the shape of

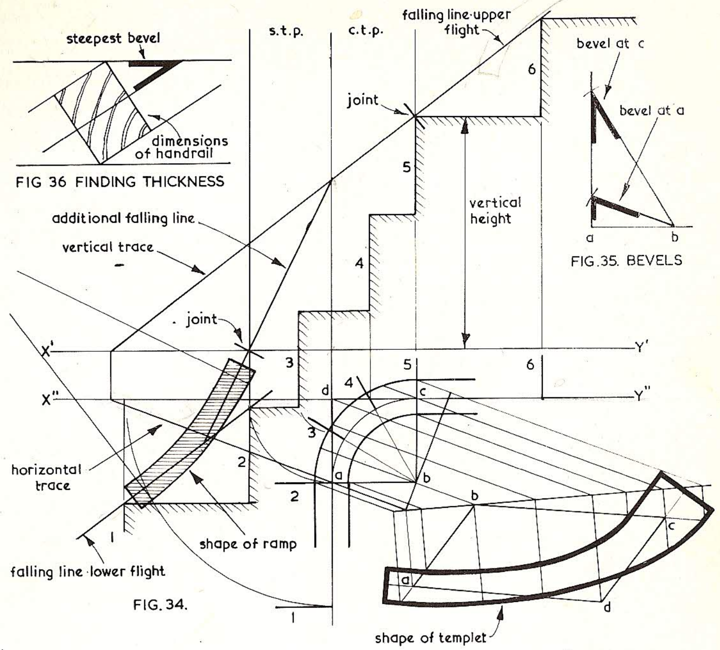


FIG 36 FINDING THICKNESS

FIG.35. BEVELS

FIG. 34.

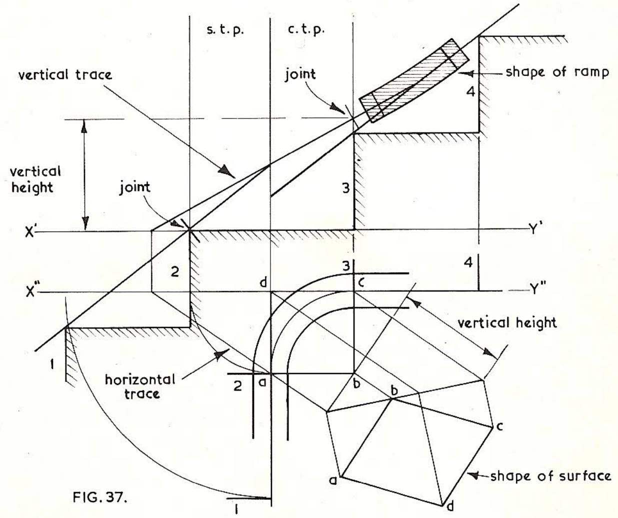


FIG. 37.

the templets. To do this the outline of the curved portion of handrail must be placed on the plan of the turn. The distance from 1–8 should be divided into a number of parts, and lines drawn from these points across the plan parallel to the horizontal trace. They should then be projected down to the 1x–8x line and from this line downwards at right angles to 1x–8x. The lengths of the lines running across the development of the surface a–b–c–d should then be made to equal those across the plan of the turn to give points on the shape of the templets. Straight sections about 2–2½ in. long are added to each end of the templet development, these straight sections being parallel to the tangent lines a′–d and c′–d. The ends of the templet must be at right angles to the tangents a′–d and c′–d.

Bevels. To obtain the bevels required to apply to the ends of the wreathed portion, first construct a right angle, Fig. 32, making a–b equal to a–b in the plan. Next place the compass point in b′ in the development of the top surface, and open them to just touch tangent a′–d. Next place the compass point in b on the right angle, Fig. 32, and cut the vertical arm in c. This will give the bevel to apply to lower end of the wreath, near a, in fact. The other bevel is obtained in the same way. With compass point in b′ open the compasses to just touch tangent c′–d, and place the compass point in b Fig. 32 and cut the vertical arm of the right angle. It will be found in this case, that the vertical arm will be cut in c, making the bevel for the top end of the wreath the same as that for the lower end. This is not always the case, as will be seen later. Fig. 33 shows the various stages in shaping the wreath.

Placing the templets. The only difference in these drawings is the positioning of the templets. As there is a bevel at each end of the wreath, care must be taken to see that the tangent lines on the templets are immediately over the lines running from the top and bottom ends of the bevels, and parallel to the tangents on the wreath (see 4th stage).

Fig. 34 is the development of the shape of the templets for a staircase of two straight flights connected by a quarter-space of winders. The stretch-out of the steps and the development of the surface a–b–c–d is straightforward if note has been made of the last example and the geometry of oblique planes.

There is, however, a complication in this and similar examples. The falling lines of the lower and upper flights do not meet, and as it

is necessary for them to meet to obtain a continuous handrail round the turn, it is essential to introduce another falling line so that this will connect the other two. This also means introducing a ramped portion of handrail in between the wreath and the lower straight handrail, as seen in Fig. 34.

The top falling line should be brought down to the vertical line immediately above d in the plan, and from here the additional falling line placed in to meet the lower falling line near riser 1. This will allow the ramp to be included—its end to be some distance, say 2 in., away from the lower joint line of the wreath, which, incidentally, must fall on line x′–y′ and the edge of the side-tangent plane. The top joint, of course, is on the edge of the cross-tangent plane.

The vertical trace is the continuance of the top falling line, and should extend down to the x′–y′ line, which passes through the lower joint, from here vertically down to the x′′–y′′ line to obtain the position of the horizontal trace.

Two bevels are required, as seen in Fig. 35, and these are developed in the way already explained. The thickness of material is found by taking the steeper of the two bevels and proceeding as before, see Fig. 36.

Fig. 37 is another staircase of two flights connected, this time by a quarter-space landing. The prism plan a–b–c–d can be seen, and the stretch-out of the steps shows that the two falling lines, again, do not meet. This time, however, the lower falling line is above the position of the upper falling line, and so it is necessary to introduce a ramp at the upper end of the curved portion of handrail. Having ascertained the position and shape of the ramped portion and the development of the templets, the bevels and thickness of material required can proceed as before.

The next problem, involving a turn in a staircase which is not a right angle (see Fig. 38), also necessitates the introduction of a ramp. The prism on which this problem is based is trapezoidal in plan. The staircase consists of two straight flights connected by winders with the risers numbered 2, 3 and 4. Again, the falling lines do not meet and a ramp must be used, this time at the lower end of the curved portion. A study of this type of oblique surface, Fig. 60, Chapter 19, will assist the reader in understanding the method used for developing the surface a–b–c–d and also the shape of the templets. The bevels are shown in Fig. 39, and are developed as before.

Some readers may find it difficult to understand the geometry used for developing the oblique surfaces in the problems on handrailing. Fig. 40 has been included in this chapter for guidance. First try to imagine that the prism (a square one in this case) has been placed in the angle set up by the vertical and horizontal planes, Fig. 40. a–b–c–d is the top surface which has to be developed. The edge c–d is projected down to the x–y line and this projected line is the vertical trace of the top surface. Another line from where the vertical line meets the x–y line and passing through the lowest corner of the top surface will give the horizontal trace. We must now try to imagine a right-angled triangle, a′–c–c′′, standing at right angles to the horizontal trace and in contact with the corner of the prism of which b is the top point. The edge c–c′′ is equal to the vertical height between the lowest and highest corners of the prism—a and c.

It should also be noted that all the lines which start from the top edge of the triangle and go across the top surface of the prism are parallel to the horizontal trace, and are therefore all horizontal lines and can be measured in the plan.

If the triangle a′–c–c′′ were turned so that it lay on the horizontal plane as seen in Fig. 40 and the various lines projected downwards at right angles to the line a′–c′ (which is now the top edge of the triangle), and all those lines made equal in length to those across the top surface of the prism, not only can the shape of the top surface be drawn but the curve a–c can also be plotted.

Dancing steps. Before leaving the subject of staircase work it will be well to consider a stair with dancing steps, Fig. 41. This staircase must not be confused with those in publications illustrating the new Building Regulations, where certain requirements are now in existence regarding winders in staircases. Readers must refer to these to ascertain what is actually required. To overcome the danger of very narrow steps near the newel post at the change of direction, it is possible to increase the widths of the winders by introducing additional tapered steps (dancing steps). From the plan Fig. 41 it will be seen that there are six of these instead of the usual three at the turn. The walking line of a staircase is the path of an individual ascending or descending the stair and this is considered to be approximately 16 in. from the outer string. When possible, it is wise to have the going of all the steps of a stair equal at the walking line, and so this should be established before

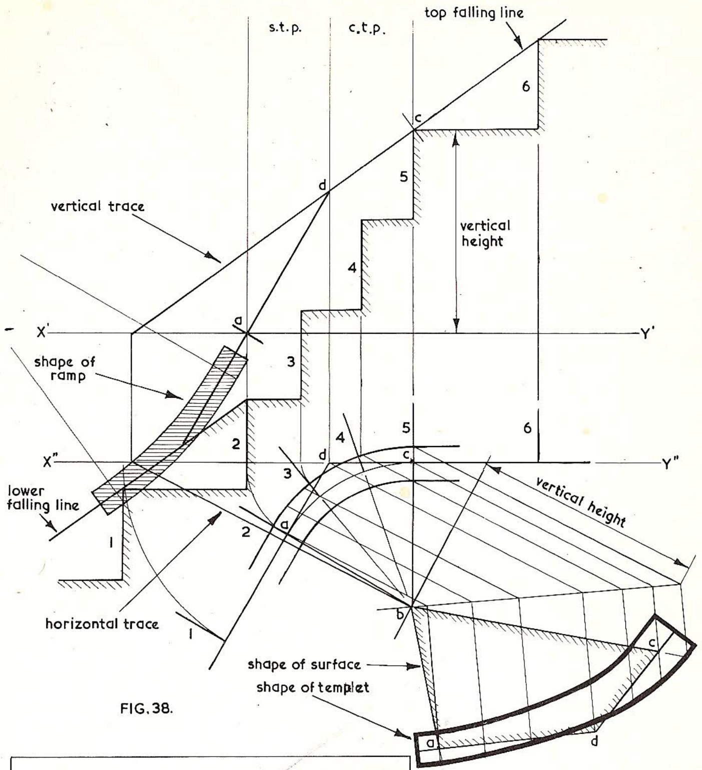


FIG. 38.

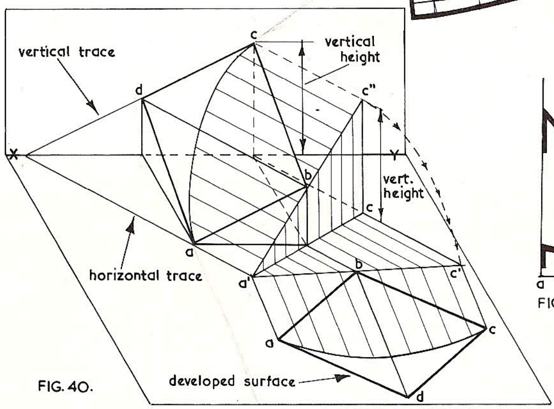


FIG. 40.

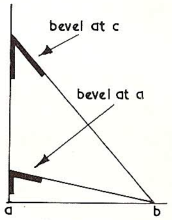
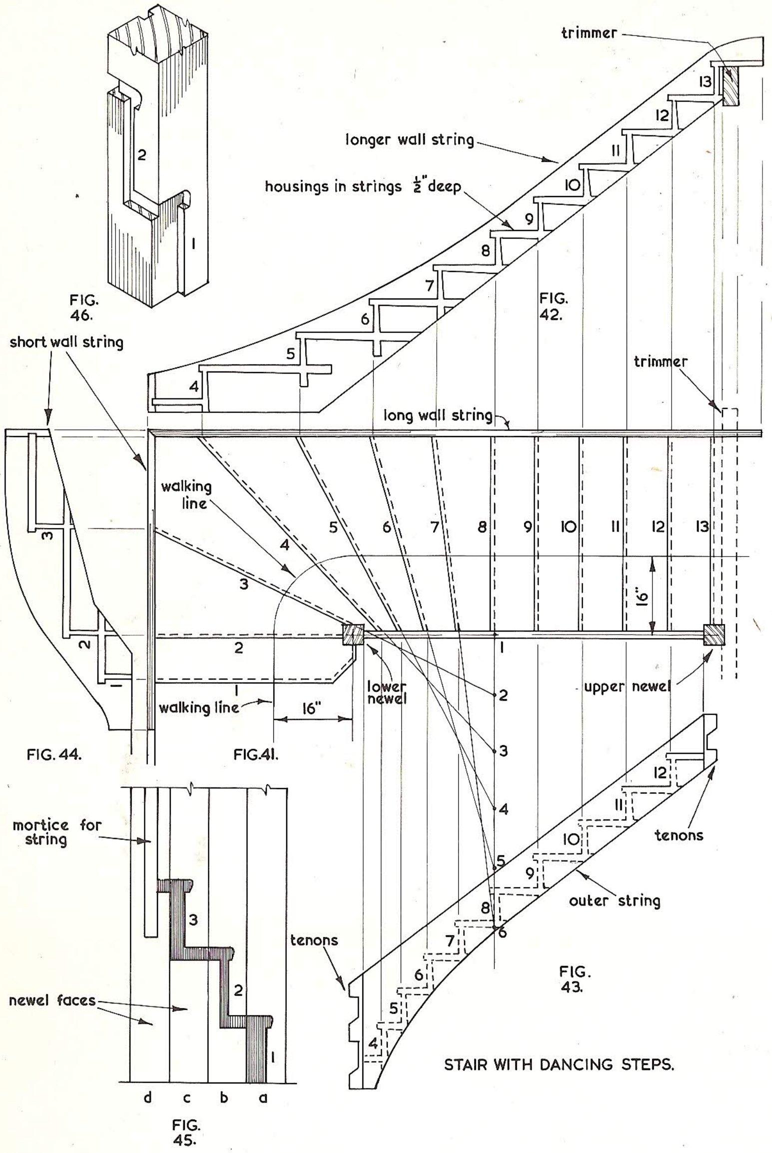


FIG. 39. BEVELS.



STAIR WITH DANCING STEPS.

setting out the positions of the risers. Having drawn the walking line on the plan and marked the 'going' on the walking line, it is necessary to decide on the number of dancing steps one is prepared to include in the flight.

To place on the drawing the positions of the risers to the dancing steps, draw a vertical line down from the first riser which is at right angles to the strings, in this case riser number 8, and mark off on this line from the centre of the outer string a number of spaces, say 12 in. apart. The number of spaces should be equal to the number of dancing or tapered steps. From these points lines can be drawn through the points on the walking line to obtain the positions of the risers to the tapered steps. It may be necessary to adjust the distances 1–2–3 etc. until a satisfactory positioning of the winder risers has been obtained.

Also shown on the drawing are methods for obtaining the shapes of the strings and the positions of the step housings, and it will be seen that the outer string has to be increased in width considerably towards its lower end because the falling line is much steeper at this point. This is due to the fact that the width of each step from number 8 downwards is narrower at the outer string than it is where it enters the long wall string. Fig. 45 shows how the four faces of the lower newel are set out for recessing, and Fig. 46 is a pictorial view of the newel. Although this type of staircase produces one which is safe and easy going, one must also remember that it is more expensive to produce.