spiral being given to describe the curve, let AB be the total height, and AC the intended height of the eye, and let the spiral be required to make two revolutions. Divide BC into four times as many parts as there are revolutions required $(4 \times 2 = 8)$, because there are four quadrants in every revolution. Draw any line DE equal to the height of the spiral. Set down from D half the number of the parts and one more $(4 + 1 = 5)$; this is the top of the eye. Set down half AC at O, and describe the eye; then at O set up half a part to F, and make FG, FH = OF; then, as in fig 105, draw OG, OH, GI, and from O draw a line parallel to GH, and divide the same into as many parts as there are to be revolutions. Fig. 105 is for one, and fig. 106 for two revolutions. Bisect O1 at X; make 2I = 2X, and join XI; and through 1 draw MN parallel to OF to meet OG and XI. Draw the quarter circles, as in the diagram,—HD being the first opening of the compasses, GP the next, and H, G, I, K, L, M, and N being the centres. To describe the scroll let AB, as in fig. 107, be the width across, usually about 10 or 12 inches; let EB be the intended diameter of the eye; and let the scroll be required to make one revolution and a half, or six quadrants (these are shown at greater size by the side of fig. 108), then proceed as last directed, and complete the scroll, also dot in the lines of the nosings and risers. For the curtail step transfer the lines of nosings *a*, and the lines of the risers *b*, to another place, as in fig. 108, and set out the thickness of the veneer within the line of nosing, the part within this represents the solid block of the curtail. The places of the balusters are shown in fig. 107.

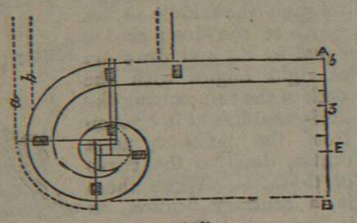

Fig. 107.

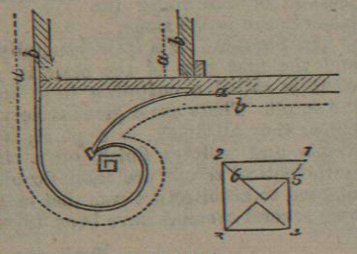

Fig. 108.

FIGS. 107, 108 illustrate the formation of Scroll and Curtail Step.

It is obvious that in every geometrical staircase, the half of a cylinder placed upright in the well-hole would touch the wreathed string in all parts, another a little less would touch all parts of the hand-rail. Let us suppose ACB, as in fig. 109, to be the plan of half a cylinder so set upright in the well-hole, and let us suppose A′E to be the height of the same. Divide the curved line ACB into any convenient number of parts, and set the same off by compasses on the straight line from C to A′ and C to B′. Or, in case ACB is a semicircle, divide the line AB, draw the diameter CD, making *a*D equal to three-fourths of the radius, and draw DA, DB′, and the rest of the lines through the points of division, as shown in the diagram. Then A′B′ is the stretch out or length of the circumference ACB unrolled. But A′E is said to be the whole height. From E set down the respective heights of the winders, step by step, as shown. Now let G be the representation of the cylinder, with the different lines squared up and across, these will give a representation of the curve at which the winders must ascend, and which, of course, must regulate the hand-rail. The other faint lines show the edge of the covering.

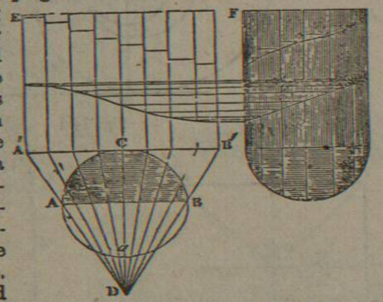

FIG. 109.—Construction of Hand-Rail.

Fig. 112 represents the plan of a staircase, beginning with a scroll, and having steps winding round the circular part of the well-hole. In the first place, let the end of the steps be developed according to the method we have just given (fig. 110 shows this development). Now the hand-rail ought to follow the inclination of a line drawn to touch the nosings of the steps, except where there is an abrupt transition from the rake of the winding to that of the other steps; at such places it must be curved,—the curve may be drawn by the help of intersecting lines, as in fig. 111. The part which is shaded in fig. 109 represents the hand-rail and ends of the steps when spread out, and the hand-rail is only drawn close to the steps for convenience, as it would require too much space to raise it to its proper position. This development of the rail is called the falling-mould. We will now refer to fig. 113, and will suppose the inner semicircle of ACB to be the plan of the well-hole, and *e*A, *a*B, the width of the rail; then the outer shaded part ACB will be the plan of the rail on the level; ADEB is the cylinder referred to before—ADE being the angle at which the stairs ascend. Now since by the principles of Conic Sections the oblique section of a circular cylinder is an ellipse, if the cylinder be circular the lines may then be found by a trammel. Be it of what section it may, the delineation of a cylinder cut at any angle ADE may be found by dividing it into equal parts, and setting up the ordinates *a*1, *b*2, &c., as shown. This delineation is a plan "on the oblique," or the face-mould of the rail, to be cut "on the plumb."

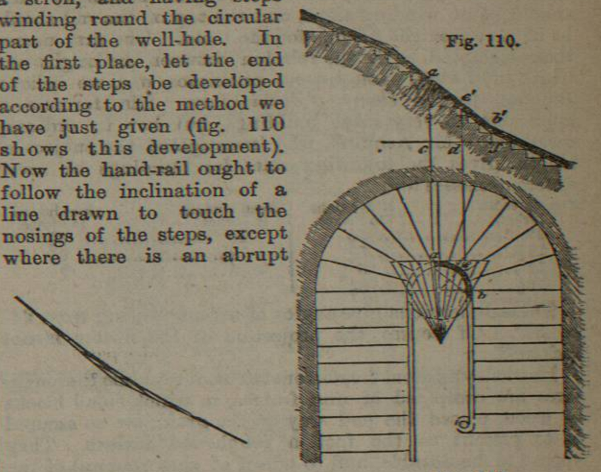

Fig. 110. Fig. 111. Fig. 112.

FIGS. 110–112.—Development of Circular Hand-Rail.

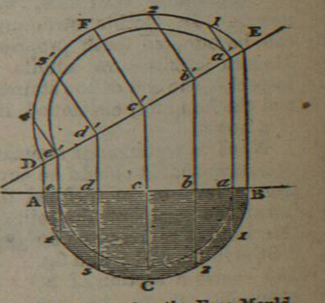

FIG. 113.—Tracing the Face-Mould of Rail.

The wood used for hand-rails being of an expensive kind, it becomes of some importance to consider how the plank may be cut so as to require the least quantity of material for the curved part of the rail. Now, if we were

to suppose the rail executed, and a plain board laid upon the upper side of it, the board would touch the rail at three points; and a plank laid in the same position as the board would be that out of which the rail could be cut with the least waste of material. Let it be required to find the moulds for the part *a b* of the rail in fig. 112, and to avoid confusing the lines in the small figure, the part *a b* has been drawn to a larger scale in fig. 114. The plain board mentioned above would touch the rail at the points marked C and B in the plan; draw the line CB, and draw a line parallel to CB, so as to touch the curve at the point E. Then E is the other point on the plan; and *a*′, *e*′, and *b*′, are the heights of these points in the development in fig. 110. Erect perpendiculars to CB, from the points C, E, and B (fig. 114), and set off C*a*′ in fig. 114 equal to *a*′*c* in fig. 110, E*e*′ equal to *d e*′, and B*b*′ equal to *f b*′. Through the points C and E, draw the dotted line C*h*; through *a*′, *e*′, draw a line to meet CE in *h*; and through the points *a*′, *b*′, draw a line to meet CB in *g*; then join *h g*, and make C*i* perpendicular to *h g*. Now, if C*d* be equal to C*a*, and perpendicular to C*i*, and *d i* be joined, it will be the angle which the plank makes with the horizontal plane, or plan. Therefore, draw FD parallel to C*i*, and thence find the section, which is the same thing as would be obtained by projecting vertical lines from each point in the hand-rail against the surface of a board laid to touch it in three points. The inexperienced workman will be much assisted in applying the moulds if he acquires a clear notion of the position when executed.

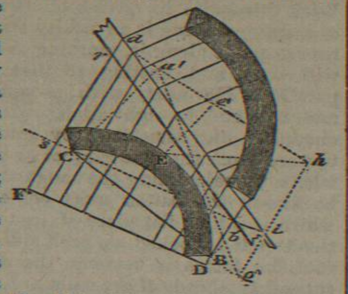

FIG. 114.—Illustrating the Tracing of Moulds.

To find the thickness of the plank, take the height to the under side of the rail *c r* in the development (fig. 110), and set it off from *s*, in the line C*i*, to *r*, in fig. 114; from the point *r* draw a line parallel to *d i*, and the distance between those parallel lines will be the thickness of the plank. The mould (fig. 114), which is traced from the plan, is called the *face mould*. It is applied to the upper surface of the plank, which being marked, a bevel should be set to the angle *i d* C, and this bevel being applied to the edge will give the points to which the mould must be placed to mark out the under side. It is then to be sawn out, and wrought true to the mould. In applying the bevel, care should be taken to let its stock be parallel to the line *d i*, if the plank should not be sufficiently wide for *d i* to be its arris. In the method fig. 113, ADE, on the rise of the stair, is the bevel. After the rail is truly wrought to the face-mould, the falling-mould (fig. 110), being applied to its convex side, will give the edge of the upper surface and the surface itself will be formed by squaring from the convex side, holding the stock of the square always so that it would be vertical if the rail were in its proper situation. The lower surface is to be parallel to the upper one. The sudden change of the width of the ends of the steps causes the soffit line to have a broken or irregular appearance; to avoid this, the steps are made to begin to wind before the curved part begins. Different methods of proportioning the ends of the steps are given by Nicholson, Roubo, Rondelet, and Krafft. We cannot in this place enter into a detail of these methods, nor can we give the varied systems of cutting the rail in the spring and in the plumb, about which so much has been written, but for the reader's information a list of the principal writers on *Staircases and Hand-Railing* subjoined.

Nothing appears to have been written on joinery until Joseph Moxon a fellow of the Royal Society, published a work entitled *Mechanick Exercises, or the Doctrine of Handyworks*, 4to, 1677. The introduction of the geometrical staircase, or stair supported on one side by the wall, invented, says Palladio, by the famous Luigi Cornaro (the first English example of which is said to be that erected in stone by Sir Christopher Wren in St Paul's Cathedral), led to the greatest changes in the art of joinery, inasmuch as the lines for setting them out necessitated a very considerable knowledge of geometry. The hand-rails of these stairs offered most difficulties, and an imperfect attempt to remove them was first made by Halfpenny, in his *Art of Sound Building*, published in 1725. Price, the author of the *British Carpenter*, published in 1733–35, was more successful, and his remarks show a considerable degree of knowledge of the true nature and object of his researches. The publication of this book must have produced a considerable sensation in the trade, for it was soon followed by many other works of different degrees of merit. Of these the publications of Langley and of Pain were the most popular, and were followed by Roubo, *L'Art de Menuisier*, folio, 1771; Skaife, *Key to Civil Architecture*, 8vo, 1774; *Transactions of the Society of Arts*, &c., for 1814; *Treatise on the Construction of Staircases and Hand-Rails*, 4to, 1820; Rondelet, *Traité de l'Art de bâtir*, tom. iv. 4to, 1814; Krafft, *Traité sur l'Art de la Charpentier*, part ii., folio, 1820; Jeakes, *Orthogonal System of Hand-Railing*, 1849; Ashpitel, *On Hand-Rails and Staircases*, 4to, 1851; Galpin, *Joiner's Instructor, Staircasing and Hand-Railing*, 4to, 1853; and Riddell, *Hand-Railing Simplified*, folio, Philadelphia, 1856 and 1860.

The establishment of the principles of joinery on the sound basis of geometrical science was reserved for Nicholson. In his *Carpenter's New Guide* and *Carpenter and Joiner's Assistant*, published in 1792, 4to, he has made some most valuable corrections and additions to the labours of his predecessors. This writer has been the founder of all the subsequent works on the subject; his books have been published again and again, in various forms, with additions from time to time, by different hands, as Galpin's *Joiner's Own Book, showing Improvements since the Days of the late Mr Nicholson*, 4to, 1856. Corresponding improvements were also made in the practice of joinery, for which we are much indebted to an architect, Mr James Wyatt.

For revived mediæval and Elizabethan joinery, particularly as adapted to windows and staircases, see Weale's *Carpentry*, 4to, 1849, and Shaw, *Details of Elizabethan Architecture*, 4to, 1839. Many modern improvements are given in Laxton's *Examples of Building Construction*, fol., 1855–58, and in Newland's *Carpenter and Joiner's Assistant*, fol., Liverpool, 1860.

The principles of joinery were cultivated in France by a very different class of writers. The celebrated Blondel, an architect of great eminence, had given details for the construction of shutters, wainscoting, doors, hinges, fastenings, &c., in his work *Distribution des Maisons de Plaisance*, 4to, 1737–38. In the extensive work of Frezier, entitled *Coupé des Pierres et des Bois*, 3 vols. 4to, 1739, all the leading principles are given and explained with tedious minuteness, offering a striking contrast to the brevity of English writers. The first elementary work on that part of geometrical science which contains the principles of joinery appeared in France in 1705, from the pen of the celebrated Gaspard Monge, who gave it the name of *Géométrie Descriptive*. The most celebrated French work which treats of joinery is Rondelet's *L'Art de bâtir*, which occupied fourteen years (from 1802 to 1816) in publication. It is also the best foreign work on the subject; but it is little adapted to the state of joinery in England. In practice the French joiners are very much inferior to the English workmen. Their work is rough, slovenly, and often clumsy, and at the best is confined to external effect. The neatness, soundness, and accuracy, which is common to every part of the works of an English joiner, is scarcely to be found in any part of the works of a French one. The little correspondence, in point of excellence, between their theory and practice leads us to think that their theoretical knowledge is confined to architects, engineers, &c., instead of being diffused among workmen, as it is in England. See also Thiollet et Roux, *Nouveau Recueil de Menuiserie*, 1837; Viollet-le-Duc, *Dict. Raisonné du Mobilier Français*, 8vo, 1858, &c.; and Nosban, *Manuel de Menuiserie*, 4to, 1849. Much also may be learned from Emy, *Traité de la Charpente*, fol., 1847—particularly with regard to framing. The publications of other nations do not call for particular notice.

CABINET-MAKING.

Cabinet-making, or that part of the art of working in wood which is applied to furniture, has some affinity with joiner the same materials and tools being employed in noth, and the mode of execution being the same. Correctness and strict uniformity are not so essential in movable, as in the fixed parts of buildings; they are also more under the dominion of fashion, and therefore are not so confined by rules as the parts of buildings. Cabinet-making offers considerable scope for taste in appropriate and beautiful forms, and also in the choice and arrangement of coloured woods. It requires considerable knowledge of perspective, and also that the artist should be able to sketch with freedom and precision. If the cabinet-maker intend to follow the higher departments of his art, it will be necessary to study the different styles of architecture, in order to make himself acquainted with their peculiarities, so as to impress his works with the same character as that of the rooms they are to furnish.

In cabinet-work the French workmen are certainly superior to the English, at least as far as regards external appearance; but when use as well as ornament is to be considered, the latter certainly carry away the palm. The appearance of French furniture is much indebted to a superior method of polishing, which is now generally known in England. The method of making and using French polish is minutely described in Dr Thomson's *Annals of Philosophy*, vol. xi. pp. 119 and 371. For many purposes, however, copal varnish (such as coachmakers use) is preferable; it is more durable, and bears an excellent polish. Foreign oak is much used for cabinet-work; and lately, the fine curled oak that is got from excrescences produced by pollard and other old trees has been used with success in furniture. When well managed it is very beautiful, and makes a pleasing variety. It is relieved by inlaid borders of black or white wood, but these should be sparingly used. Borders of inlaid brass, with small black lines, give a rich effect to the darker coloured kinds, as in buhl-work. Cedar is occasionally used for small fittings, or for cupboards where woollens and furs are stored. Ebony and imitation ebony are useful for cases. Russian birch has of late years been largely in request for bedroom furniture from the cleanly appearance of it. But of all woods mahogany has maintained its place since the first introduction of it in the end of last century. The japanner is now seldom employed to give a colour to wood, as variety can be obtained by staining, heightened by varnishing; or the plain deal or pine is polished or varnished like mahogany or oak. Patterns or lines are stencilled or burnt in according to one or other of the many patents now before the public.

Many curious works on furniture were published in the reigns of Louis XIV. and XV.; those by Sir W. Chambers and the Adams also deserve attention. Cruden's *Joiner's and Cabinet-maker's Darling*, 8vo, 1770, is a curious book. In ornamental composition much benefit may be derived from Tatham's *Etchings of Ancient Ornamental Architecture*, London, 1799; Percier and Fontaine's *Recueil des décorations intérieures comprenant tout ce qui a rapport à l'Ameublement*, Paris, 1812; and, for general information, Sheraton's *Cabinet Dictionary*, 1803, and his *Cabinet-maker and Upholsterer's Drawing-Book*, 4to, 1793, may be referred to. Bridgen's *Designs for Furniture*, fol. 1826, and Shaw's *Details of Elizabethan Architecture*, 4to, 1839, are of much value. But the most important works that can be consulted at the present time are the various illustrated publications relative to the Great Exhibitions in London and Paris (1851, 1855, and 1862), where some of the finest specimens of carpentry in the world were exhibited. The most accessible to the English reader are the *Art Journal* and the *Illustrated London News*.

Slater-work.

The slater works his material, slates, for the protection of a building by covering the roof timbers with it, in the same manner as a bricklayer works his tiles. Besides this, which is his chief business, he supplies sawn slates for shelving in larders and dairies, for tanks and cisterns, for pavements, steps, and landings, for panels of doors, for covering hips and ridges, and a few other purposes. Enamelled slate for chimney-pieces, lavatories, and similar applications is of great utility.

The slater's principal tool is a large knife or chopper Tools. called a saixe, sax, or zax, with which, before he begins to work on a roof, he shapes and trims the slates on the ground, sitting on one end of a stool, which forms a sort of bench and has uprights by which to square the slate. With this knife he strikes off the unevenness on one side of a slate, making it as nearly straight as he can; he then runs a gauge along it, marking the greatest width the slate will bear, and, cutting to that line, makes it perfectly parallel. He next, with a square, brings the thickest and best end to right angles with the sides, generally by chopping, but sometimes by sawing; and then marking upward from the squared foot or tail, makes two nail holes, where, by calculating the gauge the slate in hand will bear, he knows the batten must come. He also uses a drag, which is a long flat piece of iron having a cutting edge at the top and hooked on each side; when he has to strip a roof, he forces it between the slates, and pushes out or cuts off the heads of the nails, and thus the slate is loosened. He has also a couple of knee pads to kneel upon while at work.

The best slate obtained in Britain is from the quarries of Bangor in Carnarvonshire. The Llangollen quarries are remarkable for the size of the slates that can be obtained. The Delabole quarries in Cornwall have been worked for a considerable period, and supply a grey blue slate. Good slate is also procured in the neighbourhood of Tavistock in Devonshire. An esteemed pale blue green slate is obtained from Kendal in Westmoreland. Cumberland sea green slates are shipped from Maryport. Whitland Abbey green slates are much in vogue. The Ballachulish quarries in the north of Scotland are extensive, and supply a good quality. In Ireland are several, of which the Valentia, co. Kerry; Killaloe, co. Tipperary; Benduff, co. Cork; and those in co. Wicklow, are the best.

The best slate is of a bluish-grey colour, which breaks before the zax like well-burnt pottery, and will ring in the same manner on being struck. Whitish or light grey-coloured slate is for the most part stony; dark blue or blackish slate, on the other hand, cuts very freely, but it absorbs moisture and decays rapidly. The best slates have a hard and rough feel. whilst an open absorbent slate feels smooth and greasy.

Though slate is classed among the incombustible materials, it must not be depended upon for resisting fire, as unfortunately it will crack and fall to pieces at no very high temperature.

The scantlings of slate are cut in the quarries to set Sizes. sizes, and these are split into tablets, thicker or thinner according to the size of the slab and the nature of the slate; for the inferior qualities are neither so compact in material, nor so clearly laminated or schistose, as the superior, and will not therefore rend so freely. The sizes of slates best known in the British market are distinguished by the names of ladies, countesses, duchesses, and queens. Ladies measure 15 inches by 8, countesses 20 inches by 10, duchesses 24 inches by 12, and queens 36 inches by 24, and they are valued in proportion to their magnitude. Besides these, there is a slate which equals the queen in extent of surface, but is of very much greater thickness; this is called Welsh rag. A smaller slate, again, which is less indeed than the lady, and is cut from the refuse of large scantlings, is called a double; in size it does not often exceed 12 inches by 6. Westmoreland slates are thick and heavy like the Welsh rag, but do not generally run so large.

The principle on which slates are laid is the same as that

which is employed in plain tiling. To a roof with projecting eaves a wide board is placed over the ends of the rafters; but when the eaves tail into gutters, the gutter-board is made wide enough to receive the eaves-course For light slating it is necessary to board a roof all over with three-quarter inch rough boarding. This is done by the carpenter; but for strong heavy slates, fillets or laths or battens are considered sufficient; and these are laid by the slater himself, to suit the length of his slates. Three inches wide and one inch thick is a sufficient size for them, if the rafters be not more than 12 inches apart. Against gable or party-walls, a feather-edged board called a tilting fillet is laid to turn the water from the wall. A preferable plan, however, is to board all roofs; it gives a better bed for the slates, and fewer are broken if there be occasion for workmen to walk over them in repairing or in cleaning out the gutters. The expense, too, is but trifling beyond that of the laths. A still further benefit is obtained by bedding the slates in mortar or in hay, which fills up the spaces left by the thickness of the first slate, and with the boarding tends to keep the roof cooler in summer and warmer in winter, a very desirable result for the habitable rooms close under them. Where the roofs are finished with diagonal boarding on purlins without rafters, it makes a very sound bedding for slates. All the slates being gauged to a width, and dressed as above described, and sorted in lengths, they are then taken up to the roof in rotation, beginning with the longest and largest for the lowest courses. The first course the slater lays is little more than half the length of that which is intended to cover it, and is necessary to break the joints at the eaves. This is called the doubling eaves-course; and the covering eaves-course is brought to the same foot line, completely to cover it. Then to ascertain the gauge:—from the length of the slate deduct the bond, which should never be less than 2 inches, and need not be more than 3½ inches, and the half of what remains will be the gauge. Thus, if the bond be fixed at 3 inches, and the slate is 2 feet 3 inches in length, the gauge will be 1 foot. This gauge or margin is set up from the foot of the eaves-course at each end, and a line strained to mark it along the whole length, and so on, to the ridge or top, where another half-course is required to complete the work, and that is in its turn secured by a covering of sheet lead with a roll. To a hipped roof care is taken to complete every course up to the angle, by cutting slates to fit its slope; and these are also covered by an overlap of sheet lead with a roll, it being nailed or screwed to the hip rafter, and the head bossed over. Slate ridging with a roll, as fig. 115, or with a groove for receiving an ornamented cresting, is now very usual, and even a common ridge tiling is necessary to prevent theft of the lead in some localities.

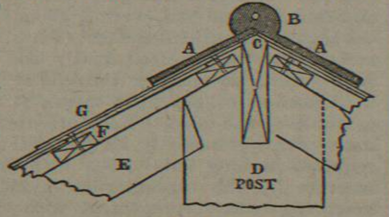

Fig. 115.—Ridge of Roof.

Fig. 116 shows specimens of the ornamental red ridging tiles occasionally used, continuously or some lengths of a plain tile apart.


Fig. 116.—Ridging Tiles.

In fig. 115, A, A are the two portions of the slate roll ridging, B being the roll with a hole drilled at each end for the insertion of a pin to fix the lengths; C the ridge piece fixed in the head of the king-post D: E the rafter; F the lath on which G, the slating, is nailed. In nailing a slate, it must not be strained or bent in the slightest degree, or it will certainly fly in some sudden atmospheric change, to which it is of course constantly liable, even if it escape fracture from being trodden on by the workmen themselves or by others. Copper, being less liable to oxidize from exposure to common causes than any other metal that will answer the purpose, should always be used for slate nails. Zinc is also occasionally used; and iron tinned and painted nails are sometimes substituted by dishonesty on the part of the workman or builder, or bad economy on that of the proprietor. The French method of fixing slates by means of wire clips which hold the bottom of the slates is unusual in England. A method has lately been introduced of effecting it with lead clips, which is said to dispense with a certain proportion of slates. Each slate is held in something of the same manner which the slater now adopts when a broken slate has to be replaced, and the main advantage is supposed to be that the slates are firmer.

The mode above described of ascertaining the gauge or margin by the bond, is equally applicable to every sort of roof-covering that is made up of small inflexible parallelogramic slabs or tablets; and it should be borne in mind that the greater the angle is at which the rafters rise, or, in technical language, the higher the pitch of the roof, the less the bond may be, and *vice versa*. With slabs or tablets that vary in length, too, as slates generally do as they are brought to market, it is the bond which it is of importance to observe; but if they are of an invariable length, as tiles are, it is sufficient that the gauge or margin be attended to.

A very light and neat covering is produced by laying Patent slating. wide slates side by side, and covering their joints with narrow slips bedded in putty, the overlap at the ends being no more than the bond is with the usual mode. It is known as patent slating, and was introduced by Mr Wyatt, who never, however, obtained a patent for it. Indeed it is in principle the mode which was adopted in ancient Greece in covering the roofs of temples. Neither boards nor fillets are used, the slates bearing from rafter to rafter, which may be 2 feet or more apart, and to the rafters the slates are screwed. The covering slips are also screwed, as well as bedded in putty. Slating of this kind may be laid at no greater elevation than 10°, whereas for slating in the ordinary way the angle should never be much less than 25°, though large slates with a 3½ inch bond, carefully laid and pointed, may perhaps be trusted at a rise of 20°. This mode of applying slate is not without the disadvantage attending the fixing of any substance that freely takes up and readily parts with heat. In expanding and contracting, the joints are too often destroyed. and leaks are the common consequence.

Thatching is an admirable covering for securing warmth Thatching in winter and coolness in summer; but it is subject to injury by birds, and to risk from fire. It is still occasionally used in picturesque cottages, arbours, and similar buildings, and was much used for churches in Norfolk and Suffolk. The thatcher requires a common stable fork, to toss up the straw together before being made into bundles; a thatcher's fork, to carry the straw from the heap up to the roof; a thatcher's rake, to comb down the straw straight and smooth; a knife, or eaves knife, to cut and trim the straw to a straight line; a knife, to point the twigs; a half glove of leather, to protect the hand when driving in the smaller twigs or spars; a long flat needle; a pair of leather gaiters to come up above the knees, used when kneeling on the rafters; and a gritstone to sharpen the knives. Wheat straw lasts from 15 to 20 years, and oat straw about 8 years. Reed thatching, as done in the West