of one of which we avail ourselves, from a house at Rheims of the 15th century (fig. 37). He gives an example also of

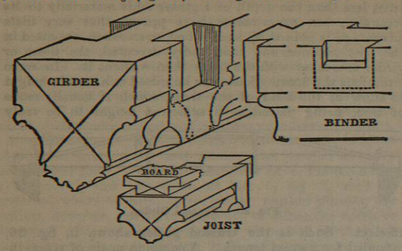


FIG. 37.—Mediæval Flooring.

a floor formed of a girder into which joists are laid formed of square timbers cut in half through the diagonal. These are fixed close together like a succession of v's, thus vvvvv, and boarded over. The top of the angle space formed by two joists is filled up with a small angle fillet presenting a flat surface. The whole effect is unique.

In mediæval carpenters' work it was always the rule only to mould the useful members, and so it was also as regards the carving. Most of the old wood carving is so contrived as to be wrought out of the same plank or thickness as that which is moulded, or else is a separate piece of wood, in a spandril for instance, enclosed within the constructional members. In joining their work, which was of oak, they trusted entirely to tenoning and pinning with stout oak pins.

Although cast-iron columns and stanchions have for some years been preferred to timber posts as supports to girders of warehouse floors; lately the latter have again come into use from their known greater resistance to fire, whereas cast-iron soon succumbs to the great heat and the effects of water upon it. Such posts are usually made of fir or of oak, the dimensions of which vary according to their compound of crushing force and stiffness which is as 25 to 40. The caps to them should be long, so that they may not press into the girders, and if practicable, iron dowels should pass through the girders to catch the bases of the posts in the floor above.

Partitions of timber are called quartering partitions, and they are generally framed. Common quartering partitions, which rest on a wall or floor, and have nothing to carry, consist merely of a sill, a head, and common uprights called studs to receive the lath for plastering; these last may be simply joggled or tenoned into the head and sill, as shown in Plate XXIV. fig. 4, *c*, and stiffened by struts or stretching pieces put between them and nailed. When, however, a quartering partition is over a vacuit/, or rests only on certain points, and has, moreover, to sustain a weight, a floor perchance, it is framed and trussed with king or queen posts and trussing pieces as to the tie-beam of a roof, and is thence called a trussed partition; and the filling in of common uprights or quarters for the laths is generally performed by joggling them at one end into either head or sill, and nailing them securely to the trussing pieces. In the diagram, Plate XXV. fig. 5, it is supposed that an opening or doorway is to be made in the partition, so that the timbers of the truss are placed around it with queen-posts, and a small internal truss is put over the door-head to prevent it from sagging, and to carry the long part of the partition, which we supposed required to bear a floor, so that the partition acts also, in fact, the part of a trussed girder in the most available form. Fig. 6 presents another method of framing a similar partition. Such partitions should be set up in every story before the beams and joists of the floors are laid, that their horizontal timbers may be notched on to the wall-plates, and that the joists or binders may be notched on to them if occasion require it; but they should be fixed rather below than above the level of the wall-plates, because they are not liable to settle down so much as the walls, though even that will depend in a great degree on the nature of the walling, and its liability to yield. As the whole weight on partitions is supported by the principal posts, their scantlings must be first considered, which should be done in two different ways: first, when the studs are to be filled in with brickwork and rendered thereon, when they are called brick-nog partitions; or secondly, when they are to be lathed and plastered on both sides, or to be wainscoted. Thin partitions of wood only are called framed partitions and are considered in the portion relating to the joiner.

Roofing

Roofing is another very important branch of the art of carpentry. The most simple form is a shed-roof or lean-to, which is merely obtained by pieces of wood being laid across in the position of an inclined plane to throw off the water. Rectangular buildings are usually covered by a roof in the form of a prism, the vertical section of which is an isosceles triangle. The height of this, or as it is technically called, the pitch of a roof, has varied in different ages, to suit the exigencies of the climate or the taste of the designer. A few examples showing the insertion of the foot of a principal rafter into a tie-beam, the struts into a post, and the heads of struts, are given in Plate XXIII.

Specialities of carpentry.

To relate all the specialities which the carpenter may have to do in some particular buildings, as a church, for instance, would far exceed our limits. The mode of executing such things would be the same as already described, the style only making a difference in the result. Pewing or benching—the pulpit and reading-desk, stalls, screenwork, font cover, gallery front, &c.—all depend on the architect's designs. Again, shop fronts are now almost a speciality, together with shop-fittings; and among the minor things in a house are the cupboards, closets, bath, cisterns, kitchen-dresser, plate-rack, dust-bin when not of wholly of brick,—also stable fittings if the improved iron fittings be not used. Centering for arches and for bridges, wharf-walls, spires, turrets, belfries, church bell hangings, gables, are all embraced in carpenter's work, as well as timber houses, the manner of framing which, and the names of the different timbers, will be found described in Le Muet's work (1747) and others of that period, and illustrated in many valuable publications, by Nash, Richardson, Habershon, Clayton, Viollet de Duc, Parker, Dollman, and others; and not least of such works in timber are the barn, porches, lych gates, palings, with chests and presses, and tables and chairs formerly.

Pugging floors, firring down joists, bracketing and cradling for plastering, and some other things, are operations performed indifferently by the carpenter or the joiner, as less or greater precision is required in the performance.

See Moxon, *Mechanick Exercises*, 4to., 1679; Godfrey Richards, *Translation of the First Book of A. Palladio*, 8vo, 1676; Smith, *Carpenter's Companion*, 8vo, 1735; Price, *British Carpenter*, 4to, 1733–35; Batty Langley, *Builder's Complete Assistant*, 8vo, 1738, and his *Builder's and Workman's Treasury of Designs*, 4to, 1740; Swan, *Carpenter's Complete Instructor*, 4to, 1759 and 1768; Pain, *British Palladio*, fol., 1786 and 1804, and his *Practical House Carpenter*, 4to, 1774; Nicholson, *Carpenter's New Guide*, 4to, 1792, his *Builder's New Director*, 4to, 1824, and his *Architectural Dictionary*, 4to, 1835; Tredgold, *Principles of Carpentry*, edit. by Barlow, 4to, 1853; Weale, *Carpentry*, 4to, 1849; Newland, *Carpenter's Assistant*, &c., fol., 1860; Laxton, *Examples of Building Construction*, large fol., 1855–58; Tarbuck, *Encyclopædia of Practical Carpentry and Joinery*, &c., 4to, 1857–59; A. W. Pugin, *Chancel Screens*, 4to, 1851, and his *Details of Ancient Timber Houses*, 4to, 1836; Bury, *Ecclesiastical Woodwork*, 4to, 1847; Brandon, *Analysis of Gothic Architecture*, 4to, 1849; Dollman, *Ancient Pulpits*, 4to, 1849; A. Pugin, *Ornamental Gables*, 4to, 1831; and the following foreign publications: Jousse, *Le Theatre de l'art de Charpentier*, fol., 1650; Le Muet, *Manière de bien bastir*, fol., 1623, translated by Pricke, fol., 1670 and 1675; Emy, *L'Art de la Charpenterie*, fol., 1841–42; Krafft, *L'Art de la Charpenterie*, fol., 1805; *L'Art de la Charpente*, fol., 1819–22, and Supplement by Thiollet, fol., 1840; Viollet de Duc, *Dictionnaire*, 8vo, 1857, &c.

JOINERY.

Joinery is one of the useful arts which contributes most materially to the comfort and convenience of man. As the arts of joinery and carpentry are often followed by the same individual, it appears at first view natural to conclude that the same principles are common to both these arts; but a closer examination of their objects leads to a different conclusion. The art of carpentry is directed almost wholly to the support of weight or pressure, and therefore its principles must be found in the mechanical sciences. In a building it includes all the rough timber-work necessary for support, division, or connection; and its proper object is to give firmness and stability. The art of joinery has for its object the addition in a building of all the fixed wood-work necessary for convenience or ornament. The joiner's works are many of them of a complicated nature, and require to be executed in an expensive material; therefore joinery requires much skill in that part of geometrical science which treats of the projection and description of lines, surfaces, and solids, as well as an intimate knowledge of the structure and nature of wood. A man may be a good carpenter without being a joiner at all; but he cannot be a joiner without being competent, at least, to all the operations required in carpentry. The rough labour of the carpenter renders him in some degree unfit to produce that kind of accurate and neat workmanship which is expected from a modern joiner; but it is no less true, that the habit of neatness and the great precision of the joiner make him a much slower and less profitable workman than the practised carpenter in works of carpentry. In carpentry, as before observed, framing owes its strength to the form and position of its parts; but in joinery, the strength of a frame depends upon the strength of the joinings. The importance, therefore, of fitting the joints together as accurately as possible is obvious. It is very desirable that a joiner should be a quick workman, but it is still more so that he should be a good one; that he should join his materials with firmness and accuracy; that he should make surfaces even and smooth, mouldings true and regular, and the parts intended to move so that they may be used with ease and freedom. It is also of the greatest importance that the work, when thus put together, should be constructed of such sound and dry materials, and on such principles, that the whole should bear the various changes of temperature and of moisture and dryness, so that the least possible shrinkage or swelling should take place.

In early times very little that resembles modern joinery was known; every part was rude, and joined in the most artless manner. The first dawnings of the art appear in the thrones, stalls, pulpits, and screens of our cathedrals and churches; but even in these it is of the most simple kind, and is indebted to the carver for everything that is worthy of regard. Whether in these monuments the carver and the joiner had been one and the same person we cannot now determine, though we imagine, from the mode of joining in some of them, that this was the case. With the revival of classic art great changes took place in every sort of construction. Forms began to be introduced in architecture which could not be executed at a moderate expense without the aid of new principles, and these principles were discovered and published by practical joiners. As might naturally be expected, these authors had but confused notions, with their scanty geometrical knowledge; and, accordingly, their descriptions are often obscure, and sometimes erroneous. The change from the heavy mullioned casement and its guard of iron bars to the sash windows necessitated some new method of protection, and boxing shutters were invented. The framed wainscot of small panels gave way to the large bolection moulded panelling. Heavy doors, which were fomerly hung on massive posts, or in jambs of cut stone, were now framed in light panels, and hung in moulded dressings of wood. The scarcity of oak timber, and the expense of working it, led to the importation of fir timber from the north, which gradually superseded all other material except for the choicest works. But the art is still far short of perfection, and in some respects it seems to have retrograded. It is seldom that large glued-up panels will now stand well. Mouldings of great girth give at the mitres, doors wind, and skirtings shrink from the floors in a way seldom seen in old houses. The sashes, perhaps, are made better than the heavy barred windows of a century and a half ago. In no other respect, however, has joinery made the progress which has been made in other arts. The improved state of machinery has also done but little for its excellence, though the circular saw-bench, the planing-machines, the moulding-machines, and the mortising-machines have done much to reduce the cost of labour. This last machine was suggested in the seventh edition of this work (1830), attention having been drawn to the subject from the improvements in the art of block-making, and it is now used in most of the large establishments throughout the country.

Tools.

The joiner operates with saws, planes, chisels, gouges, hatchet, adze, gimblets, and other boring instruments (which are aided and directed by chalked lines), gauges, squares, hammers, mallets, and a great many other less important tools; and his operations are principally sawing and planing in all their extensive varieties, setting out, mortising, dovetailing, &c. Descriptions of the tools, with instructions for using them, may be found in Moxon's *Mechanick Exercises*, 4to, London, 1677–80, and in Nicholson's *Mechanical Exercises*, London, 1812.

There is likewise a great range of other operations, none of which can be called unimportant, such as paring, gluing up, wedging, pinning, fixing, fitting, and hanging, and many things besides which depend on nailing, &c., such as laying floors, boarding ceilings, wainscoting walls, bracketing, cradling, firring, and the like. In addition to the wood on which the joiner works, he requires also glue, nails, brads, screws, and hinges,—and accessorily he applies bolts, locks, bars, and other fastenings,—together with pulleys, lines, weights, white-lead, hold-fasts, wall-hooks, &c., &c.

The joiners' work for a house is for the most part prepared at the shop, where every convenience may be supposed to exist for doing everything in the best and readiest manner; so that little remains to be done when the carcass is ready, but to fit, fix, and hang, that is, after the floors are laid. The sashes and frames, the shutters, back flaps, backs, backs and elbows, soffits, grounds, doors, &c., are all framed and put together, that is, wedged up and cleaned off, at the shop; the flooring boards are prepared, that is, faced, shot, and gauged with a fillister rebate; and the architraves, pilasters, jamb linings, skirtings, mouldings, &c., are all got out, that is, tried up, rebated and moulded, at the shop. The joiner very often turns the house he has to fit up into a workshop; for benches, and a fire for his glue-pot, are nearly all he requires, should he not have the now usual "general joiner" machine.

There is no art in which it is required that the structure and properties of wood should be so thoroughly understood as in joinery. The practical joiner, who has made the nature of timber his study, has always a most decided advantage over those who have neglected this most important part of the art.

It is well known that wood contracts less in proportion, in diameter, than it does in circumference; hence a whole tree always splits in drying. Mr Knight has shown that, in consequence of this irregular contraction, a board may be cut from a tree that can scarcely be made by any means to retain the same form and position when subjected to various degrees of heat and moisture. From the ash and the beech he cut some thin boards in different directions relatively to their tranverse septa, so that the septa crossed the middle of some of the boards at right angles, and lay nearly parallel with the surfaces of others. Both kinds were placed in a warm room, under perfectly similar circumstances. Those which had been formed by cutting across the tranverse septa, as at A in fig. 38, soon changed their form very considerably, the one side becoming hollow, and the other round; and in drying, they contracted nearly 14 per cent. in width. The other kind, in which the septa were nearly parallel to the surfaces of the boards, as at B, retained, with very little variation, their primary form, and did not contract in drying more than $3\frac{1}{2}$ per cent. in width. (*Philosophical Transactions*, part ii. for 1817; *Philosophical Magazine*, vol. l. p. 437.)

Fig. 38.

As Mr Knight had not tried resinous woods, two specimens were cut from a piece of Memel timber; and to render the result of the observations more clear, conceive fig. 38 to represent the section of a tree, the annual rings being shown by circles. BD represents the manner in which one of our pieces was cut, and AC the other. The board AC contracted 3·75 per cent. in width, and became hollow on the side marked *b*. The board BD retained its original straightness and contracted only 0·7 per cent. The difference in the quantity of contraction is still greater than in hard woods. From these experiments, the advantages to be obtained merely by a proper attention in cutting out boards for panels, &c., will be obvious; and it will also be found that panels cut so that the septa are nearly parallel to their faces, will appear of a finer and more even grain, and require less labour to make their surfaces even and smooth. But as this system would necessitate the rejection of all but the heart of the tree for superior work, a method has been adopted which it is said was first used by the billiard-table makers. Let AC, fig. 39, represent the piece above referred to by the same letters. It will become hollow on the side marked *b*, no doubt because the rings of the wood when cut across are relieved from tension, and endeavour to expand themselves. To counteract this it is customary, in all good work, to rip the plank down the centre, and then to "turn the stuff inside out" as it is popularly called. This is done by reversing the wood, end for end, so as to bring the heart against heart, and the outside against outside, as is shown in fig. 40 (without which the glue joints are sometimes liable to fly), and also so as to reverse the circular parts of the grain.

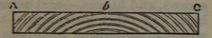


Fig. 39.

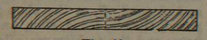


Fig. 40.

In wood that has the larger transverse septa, as the oak, for example, boards cut as BD will be figured, while those cut as AC will be plain.

There is another kind of contraction in wood whilst drying, which causes it to become curved in the direction of its length. In the long styles of framing we have often observed it; indeed, on this account, it is difficult to prevent the style of a door, hung with centres, from curving, so as to rub against the jamb. A very satisfactory reason for this kind of curving has been given by Mr Knight, which also points out the manner of cutting out wood, so as to be less subject to this defect, which it is most desirable to avoid. The interior layers of wood, being older, are more compact and solid than the exterior layers of the same tree; consequently, in drying, the latter contract more in length than the former. This irregularity of contraction causes the wood to curve in the direction of its length, and it may be avoided by cutting the wood so that the parts of each piece shall be as nearly of the same age as possible. But as this would also necessitate the rejection of a great deal of stuff, a simpler method is found, which is always to turn the heart of the wood outwards. Thus, in framing a door, the heart should always go against the jambs, and the sap side to the panels.

Besides the contraction which takes place in drying, wood undergoes a considerable change in bulk with the variations of the atmosphere. In straight-grained woods the change in length is nearly insensible, and hence they are sometimes employed for pendulum rods; but the lateral dimensions vary so much that a wide piece of wood will serve as a rude hygrometer. The extent of variation decreases in a few seasons, but it is of some importance to the joiner to be aware that even in very old wood, when the surface is removed, the extent of variation is nearly the same as in new wood.

It appears from Rondelet's experiments (*L'Art de bâtir*, article "Menuiserie," tom. iv. p. 425, 1814), that in wood of a mean degree of dryness, the extent of contraction and expansion, produced by the usual changes in the state of the atmosphere, was, in fir wood, from $\frac{1}{320}$ to $\frac{1}{76}$ of its width, and in oak, from $\frac{1}{411\frac{1}{2}}$ to $\frac{1}{85\frac{1}{4}}$. Consequently, the mean extent of variation in fir is $\frac{1}{114}$, and in oak, $\frac{1}{110}$; and, at this mean rate, in a fir board about $12\frac{1}{2}$ inches wide, the difference in width would be $\frac{1}{10}$th of an inch. This will show the importance of attending to the maxims of construction we have already laid before the reader; for, if a board of that width should be fixed at both edges, it must unavoidably split from one end to the other.

Kinds of wood.

The kinds of wood commonly employed in joinery are —the oak, the different species of pine, mahogany, and sometimes lime-tree and poplar. Of the oak there are two species common in Britain; that which Linnæus has named *Quercus Robur* is the most valuable for joiners' work; it is of a finer grain, less tough, and not so subject to twist as the other kind. Oak is also imported from the Baltic ports, from Germany (that known as wainscot), and from America. These foreign kinds being free from knots, of a straighter grain, and less difficult to work, they are used in preference to British species. The greater part of joiners' work is executed in fir imported from the north of Europe. Yellow fir is used for outside work, as doors and sashes, and for floors where there is likely to be much wear. Very good red pine deals have been imported from Canada. Inside work is almost always framed of white fir. Some very good panels when not too wide, and excellent mouldings, are made of American pine. White fir is often used for internal work, and yellow pine is much used for mouldings. The forest of Braemar, in Aberdeenshire, furnishes yellow fir of an excellent quality, little inferior to the best foreign kinds. For the general purposes of joinery, the wood of the larch seems to be the best; this useful tree thrives well on the Scottish hills. Some fine specimens of it have been obtained from Blair-

Athol. It makes excellent steps for stairs, floors, framing, and most other articles. Mahogany, in joinery, is only used where painted work is improper, as for the hand-rails of stairs, or for the doors and windows of principal rooms. For doors it is not now so often used as it was formerly, its colour being found to be too gloomy to be employed in large masses. Lime-tree, and the different species of poplar, make very good floors for inferior rooms; and may often be used for other purposes, in places where the carriage of foreign timber would render it more expensive. Lime-tree is valuable for carved work, and does not become worm-eaten; but carving is at present seldom used in joinery.

From these timbers, the oak and fir especially, the joiner obtains the battens, fillets, boards, and planks, with which he performs all his works, cutting them into scantlings and thin deals as he requires them.

Battens are narrow boards running from half an inch to an inch and a half or 2 inches thick, and from 3 to 6 or 7 inches wide. A piece of stuff of too small a scantling to be a batten is called a fillet. The term board is applied to sawed stuff when its width exceeds that of a batten, and its thickness does not exceed 2 inches or $2\frac{1}{2}$ inches. The term plank is applied to large pieces of stuff whose width is great in proportion to their thickness, and whose thickness nevertheless does not exceed 3 or 4 inches. In London these terms are used in much more restricted senses than they are here described to mean, because of the fixed and regular sizes and forms in which stuff for the joiner's use is for the most part brought to market there. A batten, to a London joiner, is a fine flooring board from an inch to an inch and a half in thickness, and just 7 inches wide. A board is a piece cut from the thickness of a deal whose width is exactly 9 inches; and nearly everything above that width, and not large enough to be called a scantling of timber, is a plank.

Mouldings, in the Roman and Italian styles, as used in joinery, are generally composed of parts of circles, and differ somewhat from those used in stone. (See Plates XIII., &c., illustrating the article ARCHITECTURE, in vol. ii.) Mouldings are almost the only part of modern joiners' work which can, in strictness, be called ornamental, and consequently that in which the taste of the workman is most apparent. The form of them should be distinct and varied, forming a bold outline of a succession of curved and flat surfaces, disposed so as to form distinct masses of light and shade. If the mouldings be of considerable length, a greater distinction of parts is necessary than in short ones. Those for the internal part of a building should not, however, have much projection; the proper degree of shade may always be given, with better effect, by deep sinkings judiciously disposed. The light in a room is not sufficiently strong to relieve mouldings, without resorting to this method; and hence it is that quirked and under-cut mouldings are so much esteemed. The following present

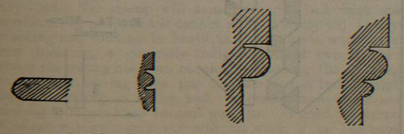


Fig. 41. Rounded Edge. Fig. 42 Bead. Fig. 43. Torus. Fig. 44. Torus and Bead.

the convex side to the eye:—fig. 41 is merely a rounded edge; fig. 42, of small size, is a bead; fig. 43, of larger size, a torus; and fig. 44 shows the torus and bead together. If there be a deep sinking under a bead (as fig. 45), it is called a quirked or cock bead; if there be two

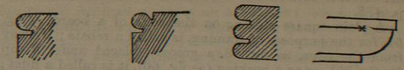


Fig. 45. Quirked Bead. Fig. 46. Double-quirked Bead. Fig. 47. Reeds. Fig. 48. Ovolo.

such sinkings, so as to show three-quarters of a circle in the bead, it is called (fig. 46) a double-quirked bead; two or more beads, side by side (as fig. 47) are called reeds;


Fig. 49.—Hollow. Fig. 50.—Flutes.

the fourth part of a circle, or half a bead (as fig. 48), is called an ovolo, or quarter round. A moulding composed of two convex parts is also called an ovolo, the upper part

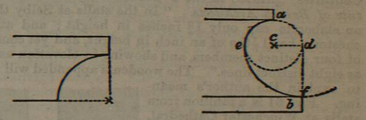
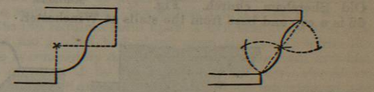
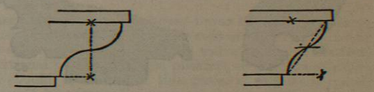


Fig. 51.—Cavetto. Fig. 52.—Scotia.

of the curve being continued round into the bed similar to a quirk, as fig. 44. In concave mouldings a simple curved grooving, as fig. 49, is called a hollow, and two or more


Figs. 53, 54.—Forms of Cyma recta.

such grooves are flutes, as fig. 50. A hollow forming the fourth part of a circle is called a cavetto, fig. 51: a


Figs. 55, 56.—Forms of Cyma reversa.

deep hollow between two fillets, as used in base mouldings, is a scotia, fig. 52. Mouldings which are partly convex

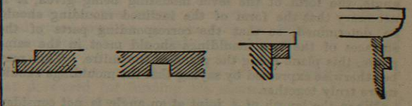


Fig. 57. Rebate. Fig. 58. Groove. Fig. 59. Necking. Fig 60. Fillet.

and partly concave, are of two sorts, the cyma recta, as figs. 53 and 54, and the cyma reversa or ogee, as figs. 55 and