THE COMPLETE MANUAL OF WOODWORKING

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SELECTING WOOD

Lumberyards usually stock spruce, fir and pine, the softwoods most commonly used for carpentry and joinery. These woods are generally sold as "dimension" or "dressed" lumber – that is, as sawn or surface-planed sections cut to standard sizes. One or more of the faces may be surfaced. Note that the planing process can remove at least $\frac{1}{8}$in (3mm) from each face of the wood, making the actual width and thickness less than the "sawn size" quoted by the wood supplier. The length, on the other hand, is always as quoted. Although the majority of hardwoods are generally sold as boards of random width and length, in some countries mahogany, teak, oak and ramin can be bought as dimension lumber. Dimension lumber is sold by the foot or in 300mm units. Check which system your supplier uses, as the metric unit is about $\frac{3}{16}$in (5mm) shorter than an imperial foot. Always allow extra on the length for waste.

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Grading

Softwoods are graded for evenness of grain and amount of allowable defects such as knots. The better-quality "appearance grades" and "nonstress grades" are probably of most interest to the general woodworker. Stress-graded softwoods are rated for structural use where strength is important. The term "clear wood" is often used for knot-free or defect-free wood, but this kind of wood is not usually available from suppliers unless specified.

The grading of hardwoods is determined by the area of defect-free wood. The greater the area, the higher the grade. The best grades are "firsts" and "firsts and seconds" (FAS).

Many specialist firms will supply wood by mail order, but whenever possible, select the wood yourself. When you go to buy wood, take a block plane with you so you can plane a small sample if the color and grain are obscured by dirt or by sawing.

WOOD DEFECTS

Unless wood is dried carefully, stresses can be introduced that mar it or make it difficult to work. Insufficient drying can lead to shrinkage of dimensioned parts, joints opening, and warping and splitting.

Before buying wood, check the surface for splits, knots and uneven grain. Look at the end section to identify the cut from the log and any distortion. Sight along the length to check for twisting or bowing.

THE PROPERTIES OF WOOD

Since wood is a product of nature, each piece is unique. Each section of wood taken from a tree, or even from the same board, will be different. It may have the same strength or color, but not the same grain pattern. It is this diversity of character, strength, color, workability and even scent that makes wood so appealing to woodworkers. Working wood is a learning process, and each piece of wood is a challenge to the worker's skills. Only by handling wood and experiencing the way it behaves can a full appreciation of its properties be gained. The natural characteristics of wood are briefly set out below, and different kinds of wood from all over the world are illustrated on the following pages.

NATURAL CHARACTERISTICS

The appearance of wood – the grain pattern, color and texture – is the prime consideration when choosing wood for a project. Its working or strength characteristics are usually a secondary consideration, but they are no less important and the wood must also be selected for fitness of purpose. If you are not familiar with a particular wood that appeals to you, discuss its properties with your supplier to make sure it will suit your requirements.

Selecting wood is a process of balancing appearance with strength, workability, pliability, weight, cost and availability. The appearance and characteristics of wood are determined by the nature of its cell structure.

Grain

The mass of the wood's cell structure constitutes the "grain" of the wood, which follows the main axis of the tree's trunk, and the nature of the grain is determined by the disposition and degree of orientation of these longitudinal cells.

Trees that grow straight and even produce "straight-grained" wood. "Cross-grained" wood is formed where the cells deviate from the main axis of the tree. Some trees twist as they grow and produce "spiral grain." In some instances the spiral growth veers from one angle to another, with each change taking place over a few growth rings; this results in "interlocked grain." "Wavy grain" and "curly grain" occur in trees that have an undulating cell structure; the former has short even waves, the latter is irregular.

Irregular-grained woods can be difficult to work and finish, as the cells constantly change direction, creating "wild grain."

Boards with random or undulating grain display various patterns according to the angle to the surface and light-reflectivity of the cell structure. These effects are exploited in the production of veneers.

The term grain is also used in referring to the way wood is cut or worked. Sawing "with the grain" refers to cuts made along the length of the wood, that is with the longitudinal cells.

Planing a surface "with the grain" follows the direction of the grain where the fibers are parallel or slope up and away from the direction of the cutting action. This results in a smooth, trouble-free cut.

Planing "against the grain" refers to cuts made where the fibers slope up and toward the direction of the planing action, producing a rough cut.

Sawing or planing "across the grain" refers to cuts made more or less perpendicular to the grain.

Figure

The term grain is commonly used to describe the appearance of wood, but what is really being referred to is a combination of natural growth features collectively known as the "figure."

The difference in growth between the earlywood and latewood, the density of the annual growth rings, the concentricity or eccentricity of the rings, the distribution of color, the effect of disease or physical damage and the method used to convert the wood into boards all contribute to the figure.

Most trees produce conically shaped trunks that when cut tangentially produce typical plainsawn boards displaying a U-shaped pattern where the layers of annual growth rings are exposed by the plane of the cut. When a log is cut radially or quartersawn, the annual rings are perpendicular to the plane of cut and the figure is less distinctive, showing a series of parallel lines. Some woods, however, have distinctive ray cells that are exposed by quartersawing and produce an attractive "ray-fleck" figure.

The form of the figure is not restricted to wood from straight trunks. The fork formed by a branch and the main stem of the tree produces "crotch" or "feather" figure much prized as veneer, as is burl wood, which is an abnormal growth caused by some injury. Stumpwood also yields interesting random-grain figure, which, like burl, can be used for turning work.

Texture

The term "texture" refers to the relative size of the wood's cells. Fine-textured woods have small closely spaced cells, while coarse-textured woods have relatively large cells. "Texture" is also used to describe the distribution of the cells in relation to the annual growth rings. Where the difference between earlywood and latewood is slight the wood is even-textured, whereas wood with marked contrast in the growth rings has an uneven texture.

A wood's texture affects not only how it cuts and planes, but also its appearance and character under a stain and final finish.

IDENTIFYING WOOD

Some common woods can be readily identified by their grain, color, texture and smell. However, unfamiliar woods can have even experts resorting to microscopic analysis of the cell structure.

The following pages show a selection of the world's commercial woods. Each wood is referred to by its standard name. Where appropriate, its commercial or local names are included.

The genus and species are given in italics. This "Latin" nomenclature is consistent worldwide, unlike commercial and local names, which can be misleading. The term "sp." or "spp." commonly means that a wood may be one of several within a genus, or "family," of trees.

The main source of supply is specified for each wood.

CONSERVATION

Unlike oil and minerals, trees are a renewable resource. However, unwise harvesting now threatens some species with extinction. The Convention on International Trade in Endangered Species of Wild Flora and Fauna, or CITES, has begun to classify certain trees for protection, in much the same way that the organization bans world trade in elephant ivory.

By agreement of participating nations, world trade in Rio Rosewood is now banned, and trees such as *Afrormosia* and *Lignum Vitae* may soon be added to the list.

To join the effort to preserve the world's threatened timbers, some suppliers now sell only those imported woods that are certified as coming from managed plantations.

SOFTWOODS OF THE WORLD

The term softwood refers to the botanical grouping of the wood rather than its physical properties. Softwoods come from coniferous trees, which belong to the botanical group Gymnospermae (plants that bear exposed seeds). Most cone-bearing trees are evergreen and have narrow, needle-shaped leaves. The standing tree is commonly depicted as having a tall, pointed outline – but not all conifers are this shape. When converted into boards, a number of softwoods are readily identified by their relatively light color range, from pale yellow to reddish brown, and by the grain pattern created by the contrast in color and density between the earlywood and latewood in the annual growth rings.

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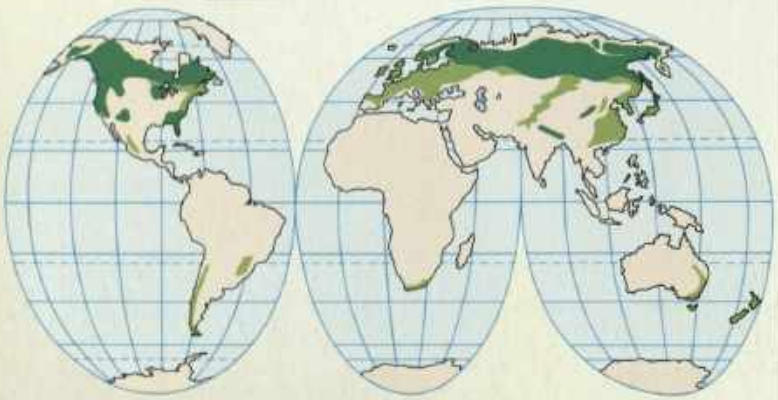


Distribution of softwoods
- Coniferous forest
- Coniferous and broad-leaved deciduous mixed forest

The scale of the map permits the areas of tree distribution to be shown in broad terms only.

The softwood regions of the world
The prime source of the world's supply of commercial softwoods is the Northern Hemisphere, which extends across the arctic and subarctic regions of Europe and North America down to the southeastern United States.

Conifers are relatively fast-growing, producing straight trunks that can be economically cultivated and harvested in man-made forests. They are cheaper than hardwoods and widely used for building construction and joinery and in the manufacture of fiberboard and paper.

Softwood boards
Whole boards of home-grown wood, complete with waney edge and bark, can be bought from local sawmills. The "waney edge" is the uncut edge of the board. Commercial boards are usually supplied debarked and square-edged. The larch example shows the bark, sapwood and mature heartwood. The sapwood is the light-colored wood, which is less resistant to fungal and insect attack than the heartwood.

Color changes
The color of wood can vary considerably, not only in the same species but also in the same tree. Most woods darken with exposure to light, though some lighten or even change color. Applied finishes, no matter how clear, tend to darken the color of the wood. The small square samples show the wood, actual size, before and after the application of a clear finish.

A simple test to see the effect of a clear finish on the color of a wood is to lick your finger and wet the surface of the wood.

CEDAR OF LEBANON
Cedrus libani
Other names: True cedar.
Sources: Middle East.
Characteristics: An aromatic wood, with light-brown heartwood. Clearly marked grain produced by contrasting earlywood and latewood. Can be knotty.
Workability: Good.
Average dried weight: 35lb/ft³ (560kg/m³).
Common uses: Interior and garden furniture, construction, joinery.
Finishing: Good.

CEDAR, WESTERN RED
Thuja plicata
Other names: Giant arbor vitae (USA); red cedar (Canada); British Columbia red cedar (UK).
Sources: Canada, USA, UK, New Zealand.
Characteristics: Relatively soft aromatic wood. Reddish brown in color, fading to silver-gray after long exposure to weathering.
Workability: Good.
Average dried weight: 23lb/ft³ (370kg/m³).
Common uses: Shingles, exterior boarding and siding, greenhouses and sheds.
Finishing: Good.

Color change
The small square samples show the actual grain size of each species and the effect when a clear finish is applied.

Cedar of Lebanon

Cedar, Western Red

CEDAR, YELLOW
Chamaecyparis nootkatensis
Other names: Alaska yellow cedar, Pacific Coast yellow cedar.
Sources: Pacific Coast of North America.
Characteristics: A pale-yellow even-textured wood, with fine straight grain. It is relatively light, stiff and stable when dry.
Workability: Good.
Average dried weight: 31lb/ft³ (500kg/m³).
Common uses: Furniture, boatbuilding, joinery, veneer.
Finishing: Good.

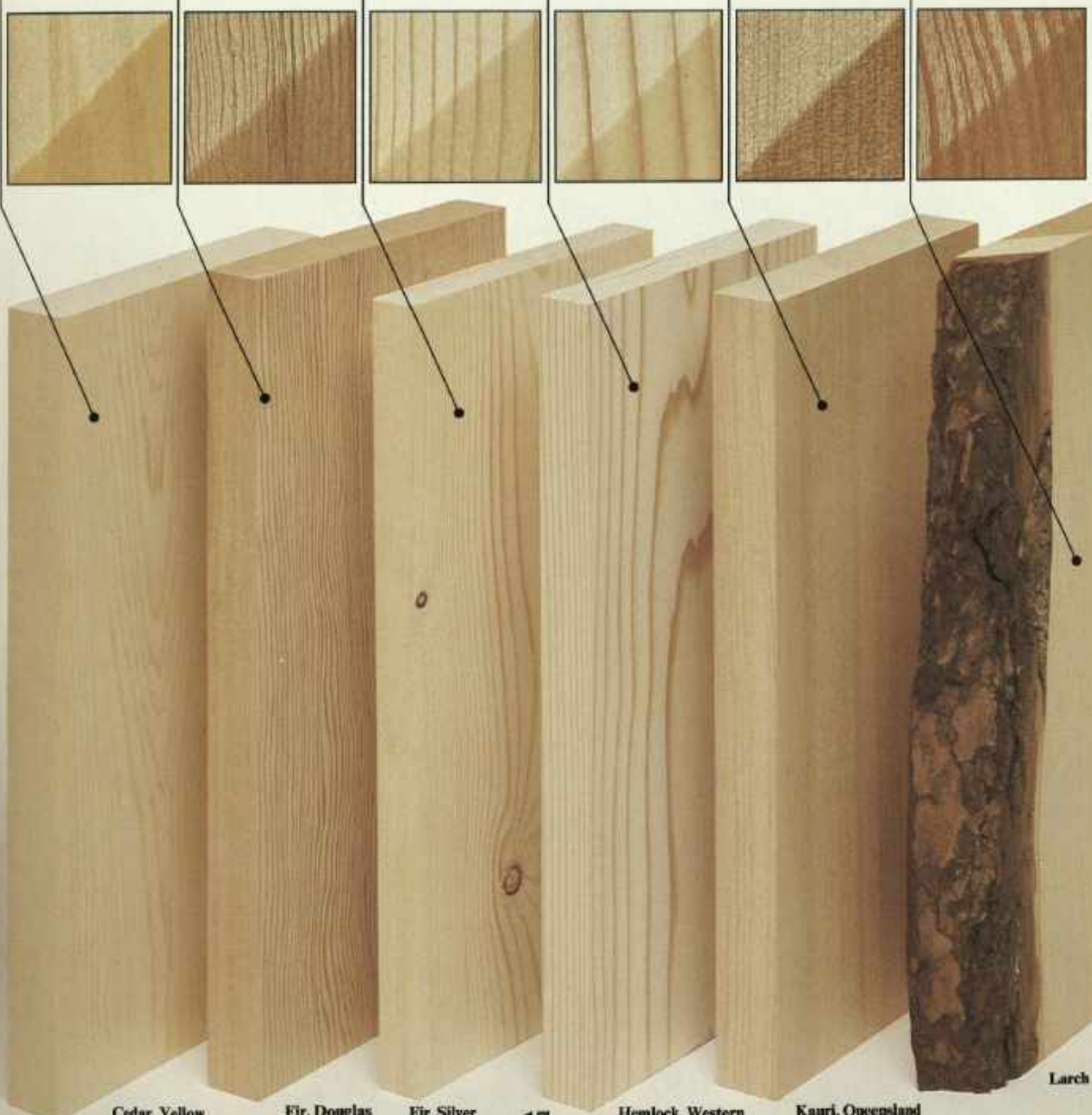
FIR, DOUGLAS
Pseudotsuga menziesii
Other names: British Columbian pine, Oregon pine.
Sources: Canada, Western USA, UK.
Characteristics: A straight-grained, reddish-brown wood, with pronounced grain. Obtainable in large knot-free sizes.
Workability: Good.
Average dried weight: 33lb/ft³ (530kg/m³).
Common uses: Plywood, joinery. Widely used in North America for building work.
Finishing: Fair.

FIR, SILVER
Abies alba
Other names: Whitewood, white fir.
Sources: Central and Southern Europe.
Characteristics: A pale-cream nonresinous and almost colorless wood, with straight grain and fine texture. Similar to and often marketed together with Norway spruce (*Picea abies*).
Workability: Good.
Average dried weight: 30lb/ft³ (480kg/m³).
Common uses: Joinery, construction, boxes, plywood, poles.
Finishing: Good.

HEMLOCK, WESTERN
Tsuga heterophylla
Other names: Pacific hemlock, British Columbia hemlock.
Sources: Canada, USA, UK.
Characteristics: A pale-brown semi-lustrous wood, with relatively distinct growth rings. It is even-textured, has straight grain and is nonresinous.
Workability: Good.
Average dried weight: 31lb/ft³ (500kg/m³).
Common uses: Construction work, joinery, plywood.
Finishing: Good.

KAURI, QUEENSLAND
Agathis spp.
Other names: North Queensland kauri, South Queensland kauri.
Sources: Australia.
Characteristics: A straight-grained wood, with fine even texture. Color varies from pale cream-brown to pinkish brown.
Workability: Good.
Average dried weight: 30lb/ft³ (480kg/m³).
Common uses: Joinery, furniture.
Finishing: Good.

LARCH
Larix spp.
Other names: Tamarack (USA).
Sources: Europe, Canada, USA.
Characteristics: Tougher than most conifers, it is a straight-grained wood of uniform texture. Pale to rich-red heartwood, light-colored sapwood. Larches shed their needles in winter.
Workability: Medium.
Average dried weight: 37lb/ft³ (590kg/m³).
Common uses: Joinery, construction, boat planking.
Finishing: Fair.



PINE, HOOP
Araucaria cunninghamii
Other names: Queensland pine (though not a true pine).
Sources: Australia, Papua New Guinea.
Characteristics: A straight-grained fine-textured wood. Similar to Parana pine in appearance, it has wide light-brown sapwood with yellow-brown heartwood.
Workability: Good.
Average dried weight: 35lb/ft³ (560kg/m³).
Common uses: Joinery, furniture, turning, construction.
Finishing: Good.

PINE, PARANA
Araucaria angustifolia
Other names: Brazilian pine (USA).
Sources: Argentina, Brazil and Paraguay.
Characteristics: Even-textured straight-grained wood, with inconspicuous growth rings. Light-brown heartwood, with dark-brown core. Often has bright-red streaks.
Workability: Good.
Average dried weight: 33lb/ft³ (530kg/m³).
Common uses: Joinery, furniture, turning.
Finishing: Good.

PINE, PONDEROSA
Pinus ponderosa
Other names: Western yellow pine, Californian white pine (USA); British Columbia soft pine (Canada).
Sources: Western Canada and USA.
Characteristics: The wide pale-yellow sapwood is soft, nonresinous and even-textured. The heavier heartwood is deep yellow to reddish brown, and resinous.
Workability: Good/fair.
Average dried weight: 30lb/ft³ (480kg/m³).
Common uses: Pattern-making, doors, furniture (sapwood); joinery, construction (heartwood).
Finishing: Fair.

PINE, SUGAR
Pinus lambertiana
Other names: Californian sugar pine.
Sources: USA.
Characteristics: Moderately soft, with medium-coarse texture and even grain. It has white sapwood and pale to reddish-brown heartwood.
Workability: Good.
Average dried weight: 26lb/ft³ (420kg/m³).
Common uses: Joinery, light construction.
Finishing: Fair.

PINE, WESTERN WHITE
Pinus monticola
Other names: Idaho white pine.
Sources: Canada, USA.
Characteristics: A straight-grained even-textured wood. Pale yellow to reddish brown, with little variation in color between early-wood and latewood.
Workability: Good.
Average dried weight: 28lb/ft³ (450kg/m³).
Common uses: Joinery, construction, furniture, boatbuilding, plywood.
Finishing: Good.

PINE, WHITE
Pinus strobus
Other names: Eastern white pine (USA); Quebec pine, Weymouth pine, yellow pine (UK).
Sources: USA, Eastern Canada.
Characteristics: A soft pine with straight grain, fine even texture and inconspicuous annual growth rings. It is pale yellow to pale brown in color, with fine resin-duct marks.
Workability: Good.
Average dried weight: 26lb/ft³ (420kg/m³).
Common uses: Pattern-making, joinery, musical instruments, furniture, construction work.
Finishing: Good.

- **Color change**
  The small square samples show the actual grain size of each species and the effect when a clear finish is applied.

Pine, Hoop | Pine, Parana | Pine, Ponderosa | Pine, Sugar | Pine, Western White | Pine, White

RIMU
Dacrydium cupressinum
Other names: Red pine.
Sources: New Zealand.
Characteristics: A fine even-textured straight-grained wood. Heartwood is reddish brown, turning to lighter shades of brown through to the yellowish sapwood.
Workability: Good.
Average dried weight: 33lb/ft³ (530kg/m³).
Common uses: Furniture, joinery, plywood, veneers.
Finishing: Good.

REDWOOD, EUROPEAN
Pinus sylvestris
Other names: Scots pine, Scandinavian redwood, Russian redwood.
Sources: Europe, Northern Asia.
Characteristics: A light-colored resinous wood, with yellow-brown to reddish-brown heartwood and light white-yellow sapwood. Distinct figure, with light earlywood and reddish latewood.
Workability: Medium.
Average dried weight: 32lb/ft³ (510kg/m³).
Common uses: Furniture, joinery, construction work.
Finishing: Good.

SEQUOIA
Sequoia sempervirens
Other names: Californian redwood.
Sources: USA.
Characteristics: A straight-grained reddish-brown wood, with marked contrast between earlywood and latewood. The texture can vary from fine and even to relatively coarse. It is nonresinous.
Workability: Fair.
Average dried weight: 26lb/ft³ (420kg/m³).
Common uses: Shingles, exterior siding, interior joinery, coffins, posts, plywood.
Finishing: Good.

SPRUCE, NORWAY
Picea abies
Other names: European whitewood, European spruce.
Sources: Europe.
Characteristics: A lustrous straight-grained even-textured wood, with almost white earlywood and pale yellow-brown latewood.
Workability: Good.
Average dried weight: 29lb/ft³ (470kg/m³).
Common uses: Construction, joinery, boxes, plywood, piano soundboards and violin bellies.
Finishing: Good.

SPRUCE, SITKA
Picea sitchensis
Other names: Silver spruce.
Sources: Canada, USA, UK.
Characteristics: A nonresinous creamy-white wood, with slightly pink heartwood. Usually straight-grained with even texture, depending on rate of growth.
Workability: Good.
Average dried weight: 28lb/ft³ (450kg/m³).
Common uses: Boatbuilding, interior joinery, construction, musical instruments, gliders, oars, racing sculls, plywood.
Finishing: Good.

YEW
Taxus baccata
Other names: Common yew, European yew.
Sources: Europe, Asia Minor, North Africa, Burma and the Himalayas.
Characteristics: A tough, hard softwood. It has an orange-red heartwood, with distinct light-colored sapwood. The growth pattern makes the wood very decorative.
Workability: Difficult.
Average dried weight: 42lb/ft³ (670kg/m³).
Common uses: Furniture, turning, joinery.
Finishing: Good.

HARDWOODS OF THE WORLD

The term hardwood (like softwood) refers to the botanical grouping of the wood rather than its physical properties. It is, however, a useful label since the majority of hardwoods are in fact harder than woods from the softwood group. The outstanding exception is balsa wood – which, although botanically a hardwood, is the softest wood in the two groups. Hardwoods come from broad-leaved trees, which belong to the botanical group Angiospermae (flowering plants). Angiosperms produce seed-bearing ovaries that develop after fertilization into fruits or nuts. This group is regarded as a higher evolutionary order than the older and more primitive coniferous Gymnosperms, which have a simpler cell structure. Most broad-leaved trees grown in temperate zones are deciduous and lose their leaves in winter – but not all, for some have developed into evergreens. Broad-leaved trees grown in tropical forests are mainly evergreen. Hardwoods are generally more durable than softwoods and offer a wider choice of color, texture and figure. They are also more expensive and many of them, particularly the highly prized exotic woods, are converted into veneer.

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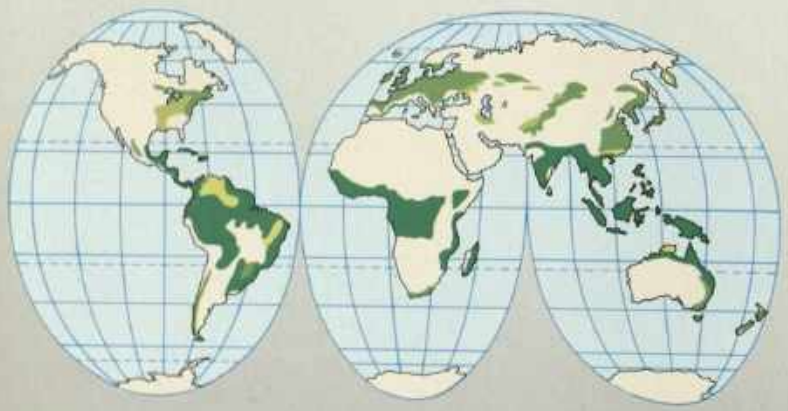


Distribution of hardwoods
- Broad-leaved evergreen forest
- Broad-leaved deciduous forest
- Broad-leaved evergreen and deciduous hardwood forest
- Broad-leaved deciduous and coniferous mixed forest

The scale of the map permits the areas of tree distribution to be shown in broad terms only.

Hardwood regions of the world
There are thousands of species of hardwood trees distributed throughout the world, hundreds of which are harvested for commercial use. Climate is the most important factor governing which species grows where. In general, deciduous broad-leaved trees are native to the temperate Northern Hemisphere and broad-leaved evergreens to the tropics and Southern Hemisphere.

Hardwoods grow relatively slowly, and, although programs for replanting help maintain the forests, the new trees are not always of such good quality as the older stock.

The map shows the distribution of broad-leaved evergreens and broad-leaved deciduous trees, evergreen and deciduous hardwoods, and broad-leaved and coniferous mixed forests.

Endangered species
The indiscriminate destruction of the world's rain forest is leading to a severe shortage of tropical hardwoods. To conserve valuable resources, use only those woods grown on plantations or managed forests. The species most at risk are marked with a felled-tree symbol.

Color change
The small square samples show the actual grain size of each species and the effect when a clear finish is applied.

AFRORMOSIA
Pericopsis elata
Other names: Assemela (Ivory Coast, France); kokrodua (Ghana, Ivory Coast); ayin, egbi (Nigeria).
Sources: West Africa.
Characteristics: A durable wood, with straight to interlocked grain. The yellow-brown heartwood darkens to the color of teak, which it resembles, though it is finer textured and not as oily as teak.
Workability: Good.
Average dried weight: 44lb/ft³ (710kg/m³).
Common uses: Veneer, interior and exterior joinery, interior and exterior furniture, construction.
Finishing: Good.

ALDER, RED
Alnus rubra
Other names: Western alder, Oregon alder.
Sources: Pacific Coast of North America.
Characteristics: A soft relatively straight-grained even-textured wood, pale yellow to reddish brown in color.
Workability: Fair.
Average dried weight: 33lb/ft³ (530kg/m³).
Common uses: Furniture, turning, carving, plywood, veneer.
Finishing: Fair.

Afrormosia

Alder, Red

ASH, WHITE

Fraxinus americana

Other names: Canadian ash, American white ash (UK).

Sources: Canada and USA.

Characteristics: A coarse but generally straight-grained wood with almost white sapwood, and pale-brown heartwood similar to European ash.

Workability: Medium.

Average dried weight: 42lb/ft³ (670kg/m³).

Common uses: Baseball bats and tool handles, boatbuilding, joinery, bentwood furniture.

Finishing: Good.

ASH, EUROPEAN

Fraxinus excelsior

Other names: English, French, Polish ash, etc. (according to origin).

Sources: Europe.

Characteristics: A tough coarse-textured straight-grained wood, whitish to pale brown in color. Logs with dark stained heartwood are known as "olive ash."

Workability: Good.

Average dried weight: 44lb/ft³ (710kg/m³).

Common uses: Sports equipment and tool handles, bentwood furniture, cabinetmaking, plywood, veneer.

Finishing: Good.

BALSA

Ochroma lagopus

Other names: Guano (Puerto Rico, Honduras); lanero (Cuba); polak (Belize, Nicaragua); topa (Peru); tami (Bolivia).

Sources: South America.

Characteristics: The softest and lightest commercial hardwood. An open straight-grained wood, with lustrous very pale beige to pinkish color.

Workability: Good.

Average dried weight: 10lb/ft³ (160kg/m³).

Common uses: Insulation, buoyancy aids, model-making, packaging.

Finishing: Fair.

BASSWOOD

Tilia americana

Other names: American lime.

Sources: Canada, USA.

Characteristics: A fine straight-grained even-textured wood. Creamy-white color, turning to pale brown on exposure.

Workability: Good.

Average dried weight: 26lb/ft³ (420kg/m³).

Common uses: Carving and turning, pattern-making, veneer, joinery.

Finishing: Good.

BEECH

Fagus grandifolia

Other names: American beech (UK).

Sources: Canada, USA.

Characteristics: Straight-grained wood, with fine even texture. Light brown to reddish brown in color, slightly coarser than European beech.

Workability: Medium.

Average dried weight: 46lb/ft³ (740kg/m³).

Common uses: Cabinetmaking, bentwood furniture, interior joinery, turning.

Finishing: Good.

BEECH, EUROPEAN

Fagus sylvatica

Other names: English, Danish, French beech, etc. (according to origin).

Sources: Europe.

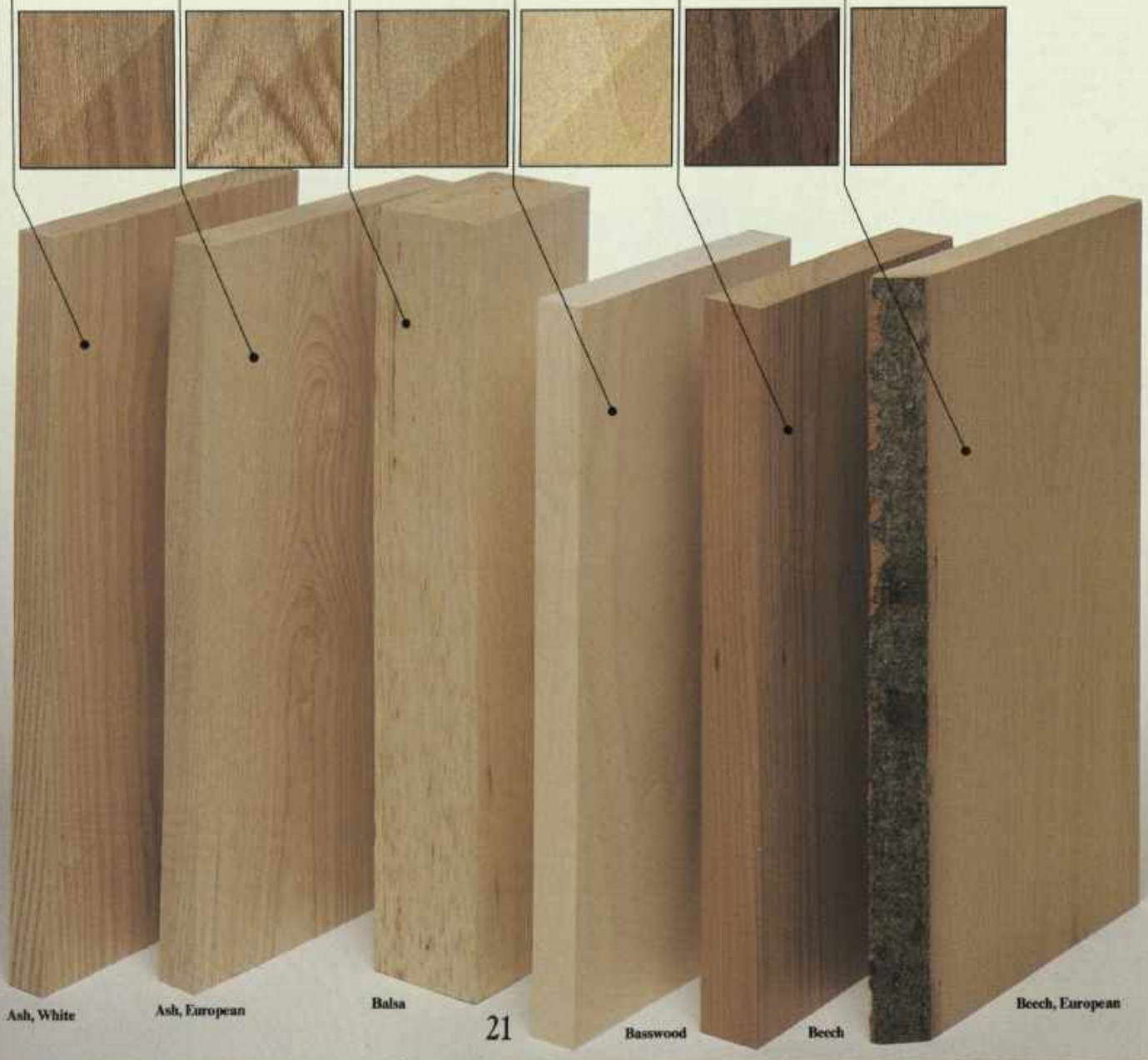
Characteristics: Straight-grained wood, with fine even texture. Whitish brown, turning to yellowish brown on exposure. "Steamed beech" is reddish brown.

Workability: Medium.

Average dried weight: 45lb/ft³ (720kg/m³).

Common uses: Cabinetmaking, bentwood furniture, interior joinery, veneer, turning, plywood.

Finishing: Good.



Endangered species
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- **Color change**
The small square samples show the actual grain size of each species and the effect when a clear finish is applied.

BIRCH, PAPER
Betula papyrifera
Other names: American birch (UK); white birch (Canada).
Sources: Canada, USA.
Characteristics: A fine straight-grained even-textured wood. It has a wide creamy-white sapwood and pale-brown heartwood.
Workability: Good.
Average dried weight: 40lb/ft³ (640kg/m³).
Common uses: Turning, kitchen utensils, plywood, veneer.
Finishing: Good.

BIRCH, YELLOW
Betula alleghaniensis
Other names: Hard birch, betula wood (Canada); Canadian yellow birch, Quebec birch, American birch (UK).
Sources: Canada, USA.
Characteristics: Straight-grained wood, with fine even texture. It has light-yellow sapwood, and reddish-brown heartwood with distinct darker-colored growth rings.
Workability: Good.
Average dried weight: 44lb/ft³ (710kg/m³).
Common uses: Furniture, joinery, turning, plywood.
Finishing: Good.

BLACKBEAN
Castanospermum australe
Other names: Moreton Bay bean, Moreton Bay chestnut, bean tree.
Sources: Eastern Australia.
Characteristics: A generally straight-grained wood, but sometimes interlocked. Hard and heavy, it is rich brown in color with gray-brown streaks.
Workability: Medium.
Average dried weight: 45lb/ft³ (720kg/m³).
Common uses: Furniture, joinery, veneer.
Finishing: Good.

BLACKWOOD, AUSTRALIAN
Acacia melanoxylon
Other names: Black wattle.
Sources: Australia.
Characteristics: Generally straight-grained, but can be interlocked and wavy. A medium and even-textured wood, with lustrous golden-brown to dark-brown color.
Workability: Medium.
Average dried weight: 42lb/ft³ (670kg/m³).
Common uses: Furniture, interior joinery, turning, billiard tables, gunstocks and decorative veneer.
Finishing: Good.

BOXWOOD
Buxus sempervirens
Other names: European, Turkish, Iranian boxwood (according to origin).
Sources: Southern Europe, Asia Minor, Western Asia.
Characteristics: A fine even-textured wood. It is dense and heavy, can have straight to irregular grain and is light yellow in color.
Workability: Medium.
Average dried weight: 58lb/ft³ (930kg/m³).
Common uses: Carving, tool handles, turning, rulers, inlay, musical instruments.
Finishing: Good.

BRAZILWOOD
Guilandina echinata
Other names: Pernambuco wood, bahia wood, para wood.
Sources: Brazil.
Characteristics: Hard and heavy, with straight grain and fine even texture. Pale sapwood, contrasting with bright orange-red heartwood turning to red-brown. Striped figure.
Workability: Medium.
Average dried weight: 80lb/ft³ (1280kg/m³).
Common uses: Dye-wood, turning, violin bows, gunstocks, exterior joinery, veneer.
Finishing: Good.

BUBINGA
Guibourtia demeusei
Other names: African rosewood; kevazingo (Gabon); essingang (Cameroons).
Sources: Cameroons, Gabon.
Characteristics: Moderately coarse even-textured wood. It can have straight or interlocked and irregular grain. Red-brown in color, with purple veining.
Workability: Good.
Average dried weight: 55lb/ft³ (880kg/m³).
Common uses: Furniture, veneer, wooden utensils.
Finishing: Good.

BUTTERNUT
Juglans cinerea
Other names: White walnut.
Sources: Canada, USA.
Characteristics: A straight-grained coarse-textured wood, with medium-brown heartwood.
Workability: Good.
Average dried weight: 28lb/ft³ (450kg/m³).
Common uses: Furniture, carving, interior joinery, veneer.
Finishing: Good.

CHERRY, BLACK
Prunus serotina
Other names: American cherry (UK).
Sources: Canada, USA.
Characteristics: A hard straight-grained wood, with fine texture. Heartwood is reddish brown to deep red, with brown flecks and some gum pockets.
Workability: Good.
Average dried weight: 36lb/ft³ (580kg/m³).
Common uses: Furniture, pattern-making, joinery, musical instruments, tobacco pipes.
Finishing: Good.

CHESTNUT
Castanea dentata
Other names: American chestnut (UK); wormy chestnut.
Sources: Canada, USA.
Characteristics: Coarse-textured, with wide growth rings. Similar to oak in appearance, but lacks broad rays. Because of blight, most lumber comes from standing dead trees. Insect attack causes "wormy chestnut."
Workability: Good.
Average dried weight: 30lb/ft³ (480kg/m³).
Common uses: Furniture, coffins, poles, stakes.
Finishing: Good.

CHESTNUT, EUROPEAN
Castanea sativa
Other names: Spanish chestnut, sweet chestnut.
Sources: Europe, Asia Minor.
Characteristics: Coarse-textured, with straight or spiralled grain. Color and texture similar to oak, but lacks oak ray figure. Reacts to ferrous metals.
Workability: Good.
Average dried weight: 35lb/ft³ (560kg/m³).
Common uses: Furniture, turning, coffins, poles, stakes.
Finishing: Good.

COCOBOLO
Dalbergia retusa
Other names: Granadillo (Mexico).
Sources: West Coast of Central America.
Characteristics: Hard, heavy, tough wood with irregular grain and medium texture. Attractive variegated color, from purple to yellow, with black markings turning to deep orange-red on exposure.
Workability: Good.
Average dried weight: 68lb/ft³ (1100kg/m³).
Common uses: Turning, knife handles, brush backs, veneer.
Finishing: Good.

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- **Color change**
The small square samples show the actual grain size of each species and the effect when a clear finish is applied.

EBONY
Diospyros ebenum
Other names: Tendu, tuki, ebans.
Sources: Sri Lanka, India.
Characteristics: A hard, dense and heavy wood with fine even texture and straight, irregular or wavy grain. The sapwood is yellowish, the heartwood dark brown to black.
Workability: Difficult.
Average dried weight: 74lb/ft³ (1190kg/m³).
Common uses: Turning, musical instruments, knife handles, inlay.
Finishing: Good.

ELM, WHITE
Ulmus americana
Other names: Water elm, swamp elm, soft elm (USA); orhamwood (Canada).
Sources: Canada, USA.
Characteristics: A coarse-textured, strong, tough, medium-density wood; usually straight-grained, but can be interlocked. Has good bending properties. The heartwood is a pale reddish brown.
Workability: Good.
Average dried weight: 36lb/ft³ (580kg/m³).
Common uses: Boat-building, cooperage, furniture, agricultural implements.
Finishing: Good.

ELM, DUTCH & ENGLISH
Ulmus hollandica/ Ulmus procera
Other names:
Dutch: Cork bark elm.
English: Red elm.
Sources: Europe.
Characteristics: Coarse-textured wood, with distinct irregular growth rings giving attractive figure. The heartwood is beige-brown in color. Sometimes in short supply because of Dutch elm disease.
Workability: Medium.
Average dried weight: 35lb/ft³ (560kg/m³).
Common uses: Furniture, bentwood furniture, turning, boatbuilding.
Finishing: Good.

GONÇALO ALVES
Astronium fraxinifolium
Other names: Zebrawood (UK); tigerwood (USA).
Sources: Brazil.
Characteristics: Hard, medium-textured wood with irregular, interlocked grain and hard and soft layers of material. Reddish brown with dark streaks, similar in appearance to rosewood.
Workability: Difficult.
Average dried weight: 59lb/ft³ (950kg/m³).
Common uses: Furniture, turning, veneer.
Finishing: Good.

HICKORY
Carya spp.
Other names: Shagbark hickory, various other species.
Sources: USA.
Characteristics: A coarse-textured wood, generally straight-grained but can be irregular or wavy. The sapwood is white, heartwood reddish brown. Pecan (*C. illinoensis*) is one of the softer hickories.
Workability: Difficult.
Average dried weight: 46lb/ft³ (740kg/m³).
Common uses: Striking-tool handles, sports equipment, chairs, bentwood furniture.
Finishing: Good.

JELUTONG
Dyera costulata
Other names: Jelutong bukit, jelutong paya (Sarawak).
Sources: Southeast Asia.
Characteristics: A soft, lustrous, fine, even-textured wood with straight grain. Creamy pale brown in color. Latex ducts may be present.
Workability: Good.
Average dried weight: 29lb/ft³ (470kg/m³).
Common uses: Pattern-making, drawing boards, interior joinery, carving.
Finishing: Good.

KAUVULA
Endospermum spp.
Other names: Sasa, New Guinea basswood.
Sources: Papua New Guinea, Solomon Islands.
Characteristics: An even-textured wood, pale yellow-brown in color, with a rather plain appearance.
Workability: Good.
Average dried weight: 30lb/ft³ (480kg/m³).
Common uses: Interior joinery and furniture.
Finishing: Good.

KINGWOOD
Dalbergia cearensis
Other names: Violet wood, violetta (USA).
Sources: South America.
Characteristics: A fine even-textured lustrous wood. The heartwood has attractive variegated striped figure of violet-brown, black, and golden yellow.
Workability: Good.
Average dried weight: 75lb/ft³ (1200kg/m³).
Common uses: Inlay, turning, marquetry.
Finishing: Good.

LAUAN, RED
Shorea spp.
Other names: None.
Sources: Philippines.
Characteristics: A relatively coarse-textured wood, with interlocked grain. The heartwood is medium to dark red in color.
Workability: Good.
Average dried weight: 39lb/ft³ (630kg/m³).
Common uses: Interior joinery, boat-building, furniture, veneer, plywood.
Finishing: Good.

LIME
Tilia vulgaris
Other names: Linden (Germany).
Sources: Europe.
Characteristics: A soft straight-grained wood, with fine uniform texture. Color white to pale yellow, darkening to light brown on exposure.
Workability: Good.
Average dried weight: 35lb/ft³ (560kg/m³).
Common uses: Broom handles, hat blocks, sounding boards, piano keys, harps, toys, clogs, carving.
Finishing: Good.

MAHOGANY, BRAZILIAN
Swietenia macrophylla
Other names: Central American, Honduras, Costa Rican, Peruvian mahogany, etc. (according to origin).
Sources: Central and South America.
Characteristics: A medium-textured wood with straight-and-even or interlocked grain. Heartwood is reddish brown to deep red.
Workability: Good.
Average dried weight: 35lb/ft³ (560kg/m³).
Common uses: Interior paneling and joinery, boat planking, carving, furniture, pianos, veneers.
Finishing: Good.

LIGNUM VITAE
Guaiacum officinale
Other names: Guayacan (Spain); bois de gaiac (France); guayacan negro, palo santo (Cuba); ironwood (USA).
Sources: West Indies and tropical America.
Characteristics: Very hard, heavy wood; has fine texture and closely interlocked grain. Heartwood is dark greenish brown to black. Naturally oily.
Workability: Difficult.
Average dried weight: 78lb/ft³ (1250kg/m³).
Common uses: Bearings, pulleys, mallets, turning.
Finishing: Good.

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MAPLE, HARD
Acer saccharum
Other names: Rock maple, sugar maple.
Sources: Canada, USA.
Characteristics: Hard, heavy, straight-grained wood with fine texture. White sapwood, with light reddish-brown heartwood. Sometimes with bird's-eye figure or curly figure.
Workability: Difficult.
Average dried weight: 46lb/ft³ (740kg/m³).
Common uses: Furniture, turning, musical instruments, butcher's blocks, flooring, veneer.
Finishing: Fair.

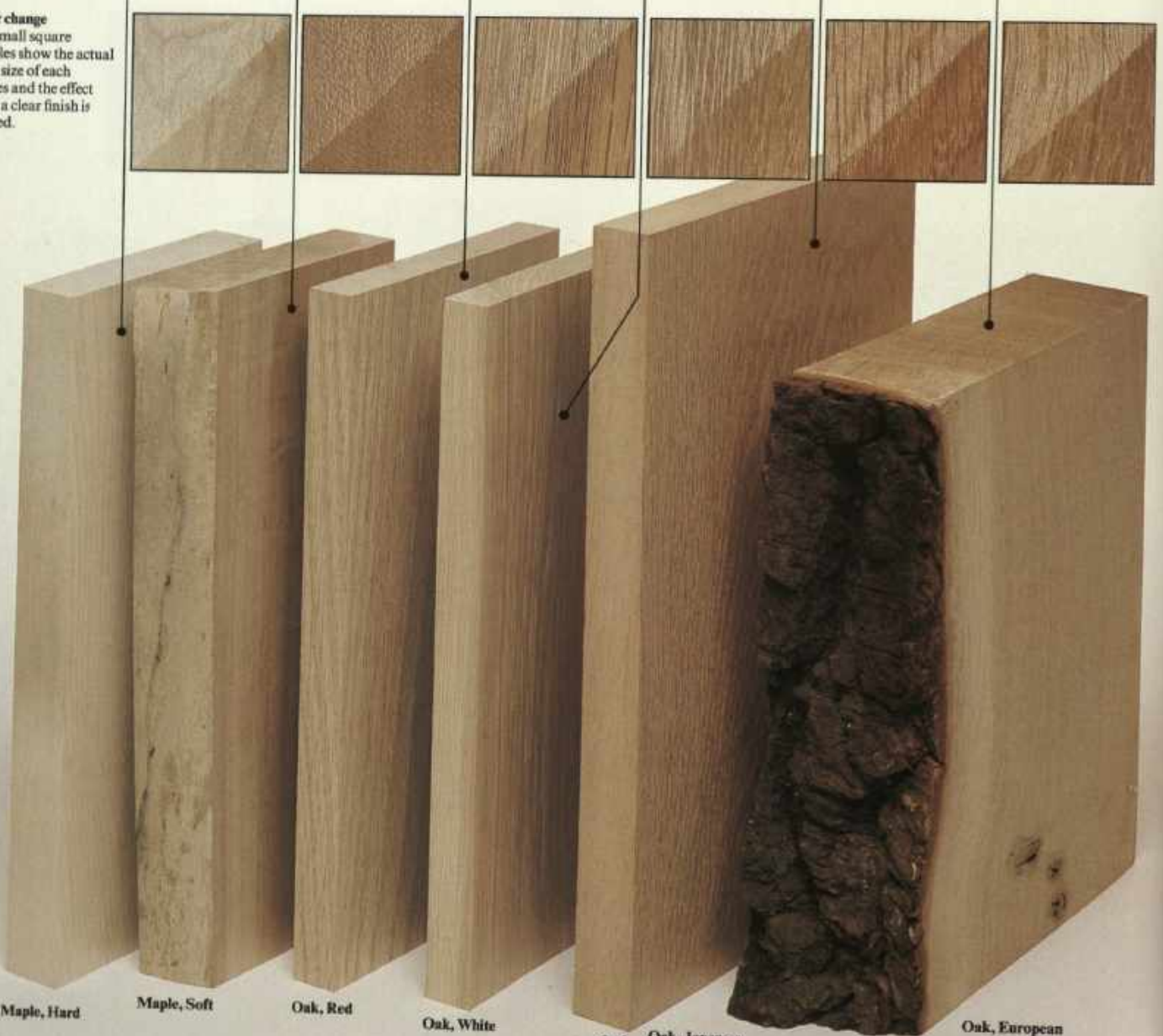
MAPLE, SOFT
Acer spp.
Other names: Red maple, silver maple, Oregon maple.
Sources: Canada, USA.
Characteristics: Straight-grained fine-textured wood, not as strong as hard maple. Light creamy-brown in color. Often with curly figure.
Workability: Medium.
Average dried weight: 39lb/ft³ (630kg/m³).
Common uses: Furniture, interior joinery, turning, veneer, musical instruments, flooring, plywood.
Finishing: Good.

OAK, RED
Quercus rubra
Other names: Northern red oak; American red oak (UK).
Sources: Canada, USA.
Characteristics: Straight-grained, with coarse texture and less attractive figure than white oak. Pinkish red in color.
Workability: Good.
Average dried weight: 49lb/ft³ (790kg/m³).
Common uses: Furniture, interior joinery, flooring, veneer.
Finishing: Good.

OAK, WHITE
Quercus alba
Other names: American white oak (UK).
Sources: USA, Canada.
Characteristics: Straight-grained, with medium-coarse to coarse texture. Similar in appearance to European oak, but more variable in color. Impervious to water.
Workability: Good.
Average dried weight: 48lb/ft³ (770kg/m³).
Common uses: Construction, flooring, furniture, interior joinery, plywood, veneer, barrels.
Finishing: Good.

OAK, JAPANESE
Quercus mongolica
Other names: Ohnara.
Sources: Japan.
Characteristics: Straight-grained and coarse-textured wood, milder than European and White oak. Light yellowish brown in color.
Workability: Good.
Average dried weight: 42lb/ft³ (670kg/m³).
Common uses: Furniture, paneling, flooring, boatbuilding, joinery, veneer.
Finishing: Good.

OAK, EUROPEAN
Quercus robur
Quercus petraea
Other names: English, French, Polish oak, etc. (according to origin).
Sources: Europe, Asia Minor, North Africa.
Characteristics: A coarse-textured and straight-grained wood, with distinct growth rings and broad rays when quartersawn. Pale brown in color.
Workability: Good.
Average dried weight: 45lb/ft³ (720kg/m³).
Common uses: Furniture, joinery, external woodwork, flooring, carving, boatbuilding.
Finishing: Good.



OBECHE

Triplochiton scleroxylon

Other names: Obechi, arere (Nigeria); wawa (Ghana); samba, wawa (Ivory Coast); ayous (Cameroons).

Sources: West Africa.

Characteristics: A lightweight rather featureless wood, with fine even texture. The grain can be interlocked. Creamy white to pale yellow in color.

Workability: Good.

Average dried weight: 24lb/ft³ (390kg/m³).

Common uses: Interior joinery, drawer linings, furniture, plywood, model-making.

Finishing: Good.

PADAUK, AFRICAN

Pterocarpus soyauxii

Other names: Padouk, camwood, barwood.

Sources: West Africa.

Characteristics: A hard, heavy wood with straight to interlocked grain and moderately coarse texture. Rich red to purple-brown color, with red streaks.

Workability: Good.

Average dried weight: 44lb/ft³ (710kg/m³).

Common uses: Interior joinery, furniture, turning, handles, flooring; known as a dyewood.

Finishing: Good.

PLANE, EUROPEAN

Platanus acerifolia

Other names: London plane; English, French plane, etc. (according to origin).

Sources: Europe.

Characteristics: Straight-grained wood, with fine to medium texture. Light reddish-brown heartwood, with distinct darker rays producing attractive fleck figure known as "lacewood" when quartersawn. Similar to but darker than American sycamore (*Platanus occidentalis*).

Workability: Good.

Average dried weight: 40lb/ft³ (640kg/m³).

Common uses: Furniture joinery, turning, veneer.

Finishing: Good.

PURPLEHEART

Peltogyne spp.

Other names: Amaranth (USA); koroboreli, saka, sakavalli (Guyana); purpleheart (Surinam); pau roxo, amarante (Brazil).

Sources: Central and South America.

Characteristics: Uniform fine to medium texture. Usually straight-grained. Attractive purple color, darkening to rich brown due to oxidation.

Workability: Medium.

Average dried weight: 55lb/ft³ (880kg/m³).

Common uses: Construction work, boatbuilding, veneer, turning, furniture.

Finishing: Good.

RAMIN

Gonystylus bancanus

Other names: Melawis (Malaysia); ramin lelur (Sarawak).

Sources: Southeast Asia.

Characteristics: Moderately fine even texture, usually straight-grained. Pale creamy-brown color.

Workability: Good.

Average dried weight: 42lb/ft³ (670kg/m³).

Common uses: Furniture, interior joinery, turning, toys, carving, flooring, veneer.

Finishing: Good.

ROSEWOOD, BRAZILIAN

Dalbergia nigra

Other names: Rio rosewood, Bahia rosewood (UK); jacaranda da Bahia, jacarando preto (Brazil); palissandre du Brazil (France).

Sources: Brazil.

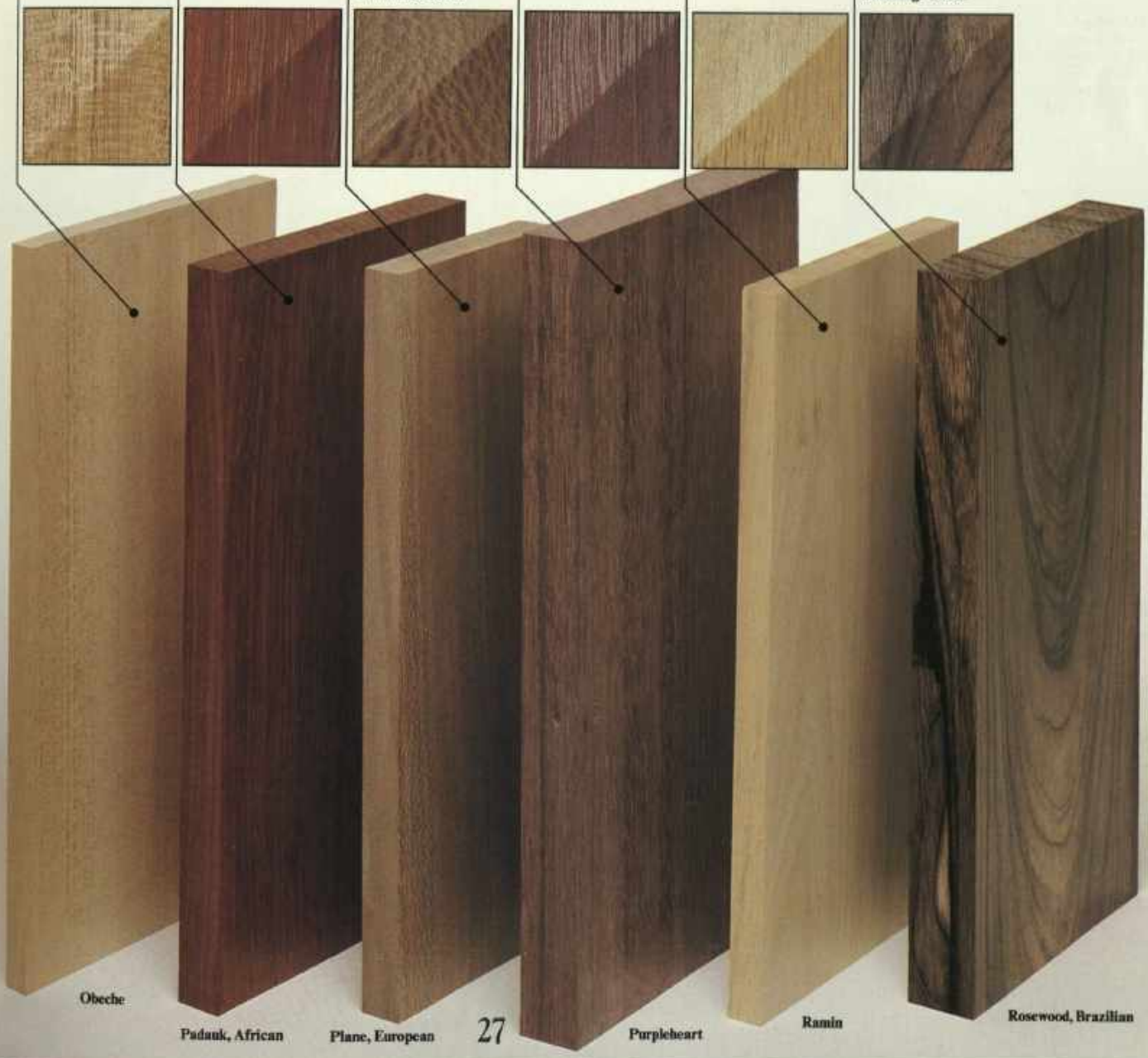
Characteristics: Hard and heavy; medium texture, with straight grain. Highly figured, with brown, violet-brown to black color.

Workability: Medium.

Average dried weight: 54lb/ft³ (870kg/m³).

Common uses: Veneer, furniture, joinery, turning, knife handles, musical instruments, carving.

Finishing: Good.



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ROSEWOOD, INDIAN

Dalbergia latifolia

Other names: East Indian rosewood; Bombay rosewood (UK); Bombay blackwood (India); palisander.

Sources: India.

Characteristics: Heavy, moderately coarse and uniform texture. Interlocked grain, producing narrow bands. Golden brown to purple-brown with streaks of dark purple or black.

Workability: Medium.

Average dried weight: 54lb/ft³ (870kg/m³).

Common uses: Furniture, shop fittings, musical instruments, boatbuilding, veneer, turning, flooring.

Finishing: Good.

SATINWOOD

Chloroxylon swietenia

Other names: East Indian satinwood.

Sources: Central and Southern India, Sri Lanka.

Characteristics: Heavy lustrous wood, with fine even texture and interlocked grain producing striped figure. Golden brown with darker streaks.

Workability: Medium.

Average dried weight: 61lb/ft³ (990kg/m³).

Common uses: Furniture, interior joinery, turning, veneer.

Finishing: Good.

SILKY OAK

Grevillea robusta

Other names: Bull oak, Northern silky oak (Australia); Australian silky oak (UK).

Sources: Australia.

Characteristics: Coarse even-textured wood, usually straight-grained with large rays. Reddish-brown color similar to red oak, though not a true oak.

Workability: Good.

Average dried weight: 34lb/ft³ (550kg/m³).

Common uses: Furniture, veneer, interior joinery.

Finishing: Good.

SYCAMORE

Platanus occidentalis

Other names: American plane (UK); buttonwood (USA).

Sources: USA.

Characteristics: Fine even texture, usually with straight grain. Not to be confused with European sycamore, which we call sycamore maple. Botanically a plane tree, but lighter than European plane. Pale brown, with distinct darker rays producing lacewood when quartersawn.

Workability: Good.

Average dried weight: 35lb/ft³ (560kg/m³).

Common uses: Joinery, furniture, butcher's blocks, veneer.

Finishing: Good.

SYCAMORE, EUROPEAN

Acer pseudoplatanus

Other names: Sycamore, sycamore plane, great maple (UK); sycamore maple (USA).

Sources: Europe, Western Asia.

Characteristics: A maple, not a true sycamore (plane). Fine even texture. Straight-grained but may have fiddleback figure when quartersawn. White to yellowish-white color.

Workability: Good.

Average dried weight: 39lb/ft³ (630kg/m³).

Common uses: Turning, furniture, kitchen utensils, flooring. Fiddleback wood is used for violin backs.

Finishing: Good.

TEAK

Tectona grandis

Other names: Kyun sagwan, teku, teka.

Sources: South and Southeast Asia, Africa, Caribbean.

Characteristics: Coarse uneven texture with oily feel. Straight or wavy-grained, according to origin. Burma teak is a uniform golden brown; others are darker and more marked.

Workability: Good.

Average dried weight: 41lb/ft³ (660kg/m³).

Common uses: Interior and exterior joinery, boatbuilding, exterior and garden furniture, plywood, turning, veneer.

Finishing: Good.

TULIPWOOD
Dalbergia frutescens
Other names: Pinkwood (USA); bois de rose (France); pau rosa, jacaranda rosa, pau de fuso (Brazil).
Sources: Brazil.
Characteristics: Dense, hard wood with medium to fine texture; usually has irregular grain. Attractive pinkish-yellow color, with pink to violet-red stripes.
Workability: Difficult.
Average dried weight: 60lb/ft³ (960kg/m³).
Common uses: Turning, kitchen utensils, boxes, inlay, veneer.
Finishing: Good.

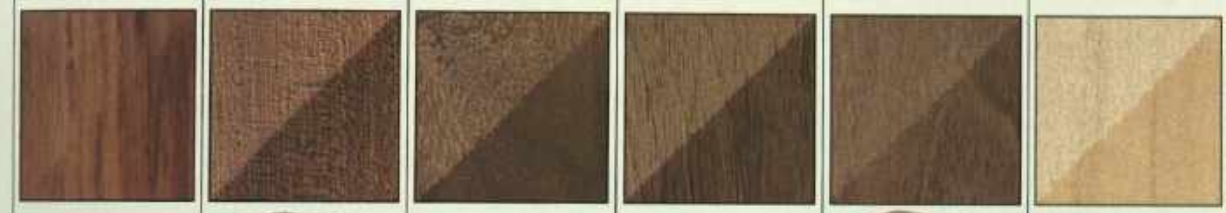
UTILE
Entandrophragma utile
Other names: Sipo (Ivory Coast); assie (Cameroons).
Sources: Africa.
Characteristics: A medium-textured wood; usually with interlocked grain, producing striped figure when quartersawn. Pinkish-brown color, turning to red-brown.
Workability: Good.
Average dried weight: 41lb/ft³ (660kg/m³).
Common uses: Furniture, interior and exterior joinery, boat-building, flooring, plywood, veneer.
Finishing: Good.

WALNUT, BLACK
Juglans nigra
Other names: Black American walnut, American walnut, Virginia walnut (UK); walnut (USA).
Sources: USA, Canada.
Characteristics: A tough wood, with rather coarse texture; usually straight-grained, but can be wavy. Rich dark brown to purplish black.
Workability: Good.
Average dried weight: 41lb/ft³ (660kg/m³).
Common uses: Furniture, gunstocks, interior joinery, musical instruments, turning, carving, plywood, veneer.
Finishing: Good.

WALNUT, EUROPEAN
Juglans regia
Other names: English, French, Italian walnut, etc. (according to origin).
Sources: Europe, Asia Minor, Southwest Asia.
Characteristics: Rather coarse texture, with straight to wavy grain. Gray-brown with darker streaks, though color and markings vary according to origin.
Workability: Good.
Average dried weight: 42lb/ft³ (670kg/m³).
Common uses: Furniture, interior joinery, gunstocks, turning, carving, veneer.
Finishing: Good.

WALNUT, QUEENSLAND
Endiandra palmerstonii
Other names: Australian walnut, walnut bean, Oriental wood.
Sources: Australia.
Characteristics: Similar to European walnut in appearance, but not a true walnut. Usually has interlocked and wavy grain. Wide color variation, from light to dark brown.
Workability: Difficult.
Average dried weight. 43lb/ft³ (690kg/m³).
Common uses: Furniture, interior joinery, shop fittings, flooring, veneer.
Finishing: Good.

YELLOW-POPLAR
Liriodendron tulipifera
Other names: Whitewood, tulip poplar (USA); tulip tree (UK and USA); canary whitewood (UK).
Sources: Eastern USA, Canada.
Characteristics: A moderately soft and lightweight wood, with straight grain and fine texture. White sapwood; pale olive-green to brown heartwood, with colored streaks.
Workability: Good.
Average dried weight: 31lb/ft³ (500kg/m³).
Common uses: Joinery, furniture, carving, light construction, interiors, boats, toys, plywood.
Finishing: Good.



Tulipwood
Utile
Walnut, Black
Walnut, European
Walnut, Queensland
Yellow-poplar

MAN-MADE BOARDS

Man-made boards are relatively new and have been taken up enthusiastically by industry and the home woodworker alike. Board manufacturers are constantly developing their products with a view to improving quality, economy of raw materials and ease of working. Consequently, there is a wide range of boards available today. These fall into roughly three categories: laminated boards, particleboards and fiberboards. As new products are introduced, some kinds of laminated boards, such as solid-core blockboard, may be replaced by cheaper particleboard and fiberboard types.

SEE ALSO

Softwoods	16-19
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Cabinet construction	63,65,70
Board joints	246-247
Working man-made boards	248

PLYWOOD

Plywood is a laminated material made from thin sheets of wood known as construction veneers, plies or laminates, that are bonded in layers to form a strong stable board. Laminating wood was a technique known to craftsmen in ancient times, but plywood is a relatively modern material first produced commercially around the mid-nineteenth century. Its panel size, stability and ease of working made it a useful material for interior joinery and carcase construction, but it was not until the development of waterproof adhesives in the 1930s that it found a place in the construction industry.

Plywood construction

A board of solid wood is relatively unstable and will shrink or swell to a greater degree across the fibers than it will along them. In so doing it is also likely to distort, depending on how it is cut from the tree. The tensile strength of wood is greatest following the direction of the fibers, but it will also readily split with the grain.

Plywood is constructed with the fibers or grain of alternate plies set at right angles to one another to counter movement of the wood. This produces a stable warp-resisting board that has no natural direction of cleavage. The greatest strength of a panel is usually parallel to the face grain.

Most plywood is made with an odd number of plies to give a balanced construction, three being the minimum. The number varies according to the thickness of the plies and the finished board. Whatever the number, the construction must be symmetrical about the center ply or the centerline of the panel thickness.

The surface veneers of a typical plywood board are known as "face plies." Where the quality of one of the outer plies is better than the other, the better ply is called "the face" and the other "the back." The grade of the face and back plies is usually specified by a letter code. The perpendicularly laid plies immediately beneath the face plies are known as "cross-bandings." The center ply (or plies) is known as "the core."

Sizes

Plywood is made in a wide range of sizes. The thickness of commercially available plywood generally ranges from $\frac{1}{8}$in (3mm) to 1 $\frac{3}{16}$in (30mm), in approximately $\frac{1}{8}$in (3mm) increments. Thinner "aircraft plywood" is available from specialist suppliers.

The typical width of a board is 4ft (1.22m), but 5ft (1.52m) boards are also available. The most common length is 8ft (2.44m), although boards up to 12ft (3.66m) are made. The dimensions are expressed in imperial or metric measurements depending on the source of manufacture or supply.

The grain of the face ply usually follows the longest dimension of the board, but not always. Grain may run parallel to the first dimension quoted by the manufacturer or supplier. Thus a 4 × 8ft (1.22 × 2.44m) board will have the grain running across the width. Ask if your supplier follows this system.

BONDING

The performance of plywood is determined not only by the quality of the plies but also by the type of adhesive used in its manufacture. Plywoods can be grouped according to usage.

Interior plywood

Plywoods of this grade should be used only for non-structural interior applications. They are generally produced with an appearance-grade face ply and a poorer quality for the back.

Interior plywoods are manufactured with urea-formaldehyde adhesive, which is light in color. Most boards are suitable for use in dry conditions, such as furniture or wall paneling. Modified adhesive employed in the manufacture of certain types of board affords them some degree of moisture resistance, enabling them to be used in areas of high humidity. Never use interior-grade plywood for exterior applications.

Exterior plywood

Exterior-grade plywoods can be used for fully or semi-exposed conditions (depending on the quality of the adhesive), where structural performance is not required.

Boards suitable for fully exposed conditions are bonded with dark-colored phenol-formaldehyde (phenolic) adhesive. This type produces "weather and boil proof" (WBP) plywood. WBP adhesives comply with an established standard and systematic tests, as well as their record in service over many years, have proved them to be highly resistant to weather, micro-organisms, cold and boiling water, steam and dry heat.

Exterior-grade plywoods are also produced using melamine urea-formaldehyde adhesive. This type of board is semi-durable under exposed conditions.

Exterior-grade plywood is a good material for kitchen cabinets and for applications around showers or bathrooms.

Marine plywood

Marine plywood is a high-quality face-graded structural plywood primarily produced for marine use. It is constructed from selected plies from a limited range of mahogany-type woods. Marine ply has no "voids," or gaps, and is bonded with a durable phenolic (WBP) adhesive. It can also be used for interior cabinets.

Structural plywood

Structural or engineering-grade plywood is manufactured for applications where strength and durability are the prime consideration. It is bonded with phenolic resin adhesive. An appearance-grade face ply of a lower quality is used, and the boards may not have been sanded. Many of these plywoods are "pressure treated" with chemical salts to retard rotting.

TYPES OF PLYWOOD

Different types of plywood are produced for such diverse applications as agricultural installations, aircraft and marine construction, structural building work, interior cabinets, toys and furniture. Performance and suitability of application depend on species of wood, type of bond and grade of veneer.

Plywood boards are manufactured in many parts of the world and the species of wood used varies according to place of origin. The face veneers and core may be made from different species or the boards may be constructed from the same species throughout.

Softwood boards are commonly made from Douglas fir or various species of pine; common hardwood types from light-colored temperate woods such as birch, beech and basswood. Tropical woods used for plywood construction include lauan, meranti and gaboon, all of which are red in color.

APPEARANCE GRADING

Plywood manufacturers use a coding system to grade the quality of the plies used in the manufacture of their boards.

A typical system uses the letters A, B, C, C-plugged and D. The A grade is the best quality, being smooth-cut with virtually no defects. The D grade is the poorest, having the maximim amount of permitted defects, such as knots, holes, splits and discoloration.

The letters quoted or stamped on the board refer to the appearance of the face plies only and do not indicate the structural performance of the board. An A-A grade plywood has two good faces, while a B-C board has poorer-grade outer plies (the better B grade being the face and the C grade the back). Decorative plywoods are faced with selected matched veneers, and are referred to by the face veneer.

Decorative plywood is faced with selected flat-sliced or quarter-cut matched veneers, usually of hardwoods such as afrormosia, beech, cherry or oak, and is mainly used for paneling. A balancing veneer of lesser quality is applied to the back of the board.

Three-ply board has the face veneers bonded to a single core veneer. Their thickness may be the same, or the core may be thicker to improve the balance of the construction. This type is sometimes called "balanced" or "solid-core" plywood. Thin three-ply boards are used for drawer bottoms and cabinet backs.

Drawer-side plywood is the exception to the cross-banding construction method. This type has the grain of all the plies running in the same direction. It is made of hardwood to a nominal thickness of $\frac{1}{2}$in (12mm) and is used for drawer sides in place of solid wood.

Multi-ply has a core consisting of an odd number of plies. The thickness of each ply may be the same, or the cross-banded ones may be thicker. This helps give the board equal stiffness in its length and width. It is a good material for use in making veneered furniture.

Four-ply and six-ply Four-ply has two thick-cut plies bonded together, with their grain in the same direction and perpendicular to the face plies. This type is stiffer in one direction and is usually used for structural work. Six-ply (shown here) is similar to four-ply in construction but has the core parallel to the face, with cross-banded ply in between.

BLOCKBOARD AND LAMINBOARD

Blockboard is a form of plywood, being of laminated construction. It differs from conventional plywood in that the core is constructed from strips of solid wood cut approximately square in section and edge-butted, but not glued. The core is faced with one or two layers of ply on each side.

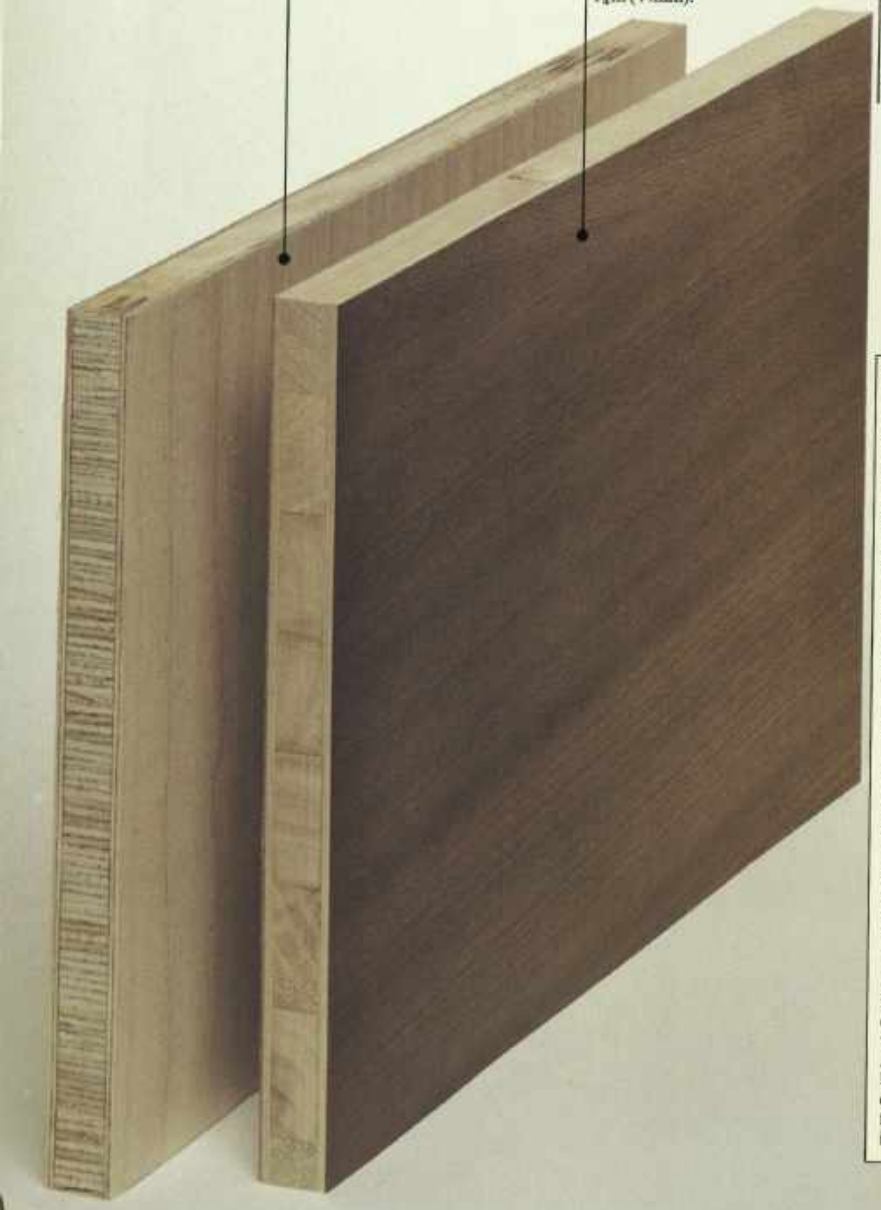
Laminboard is similar to blockboard but the core is constructed from narrow strips approximately $\frac{1}{5}$in (5mm) wide, which are usually edge-glued.

SEE ALSO

Cabinet construction	63,65,70
Home workshop	210-211
Veneering	258-270
Wood screws	304-305
Knock-down fittings	308

Laminboard
is superior to blockboard for veneer work, as the core is less likely to show through. It is also more expensive. Boards of three-ply and five-ply construction are produced. The plies of the five-ply type may either be perpendicular to the core or cross-banded.

Blockboard
is a stiff material suitable for furniture applications, particularly shelving and worktops. It makes a good substrate for veneer work, but the core strips can "telegraph" (i.e. show through). It is made in panel sizes similar to plywood, in thicknesses ranging from $\frac{1}{2}$in (12mm) to 1in (25mm). Thicker boards of three-ply are made up to $1\frac{3}{4}$in (44mm).



PARTICLEBOARDS

Wood-particleboards are made from small chips or flakes of wood bonded together under pressure. Various types are produced according to the shape and size of the particles, their distribution through the thickness of the board and the type of adhesive used to bind them together. Softwoods are generally used, although a proportion of hardwood material is sometimes included.

Types of board

Particleboards are stable and uniformly consistent materials. Those constructed with fine particles have featureless surfaces and are highly suitable as groundwork for veneer. A wide range of preveneered decorative boards using wood, paper foil or plastic laminates are available. Most particleboards are relatively brittle and have a lower tensile strength than plywood.

Chipboard

Most types of particleboard of interest to the woodworker are of interior quality, commonly known as chipboard. Chipboard, like other wood products, is adversely affected by excess moisture – the board swells in its thickness and does not recover when dried. However, moisture-resistant types suitable for flooring or wet conditions are made.

STORING AND USING BOARDS

Storing boards
To save space, store boards on edge. Make a rack to keep the edges clear of the floor and support the boards evenly at a slight angle. When storing thin boards, support the full area of each board with a thicker board underneath.

Using boards
Screws attached to the edges of man-made boards are not as strong and secure as those attached to the face.

Drill pilot holes in the edge of plywood to prevent splitting. The diameter of the screws used should not exceed 25 percent of the board's thickness.

Blockboard and laminboard will hold screws well in the side edges, but not in the end grain.

Screw holding in chipboard depends on the density of the board. It is usually relatively weak, but special chipboard screws hold better than standard wood screws. Always drill pilot holes, both for face screws and edge screws. Use special fastenings or inserts for improved holding.

Single-layer chipboard is made from a mat of similar-sized particles evenly distributed throughout. It has a relatively coarse surface. This type is suitable for wood veneer or plastic laminate, although not for painting.

Three-layer chipboard has a core layer of coarse particles sandwiched between two outside layers of fine high-density particles. The outer layers contain a higher proportion of resin, which produces a smooth surface suitable for most finishes.

Graded-density chipboard has surfaces of very fine particles and a core of coarser particles. Unlike layered types, there is a gradual transition from the coarse particles to the fine surface.

Decorative chipboard is manufactured with a facing of selected wood veneer, plastic laminate or a thin melamine foil. The wood-veneered boards are sanded ready for polishing; the foil-faced and plastic-laminated boards need no finishing. Some plastic-laminated boards for worktops are made with finished profiled edges, while matching edging strips are available for lipping melamine-faced and wood-veneered boards.

Oriented-strand board is a three-layer material made from long strands of pine. The strands in each layer are laid in one direction, and each layer is perpendicular to the next in the same manner as plywood.

Flakeboard or waferboard uses large shavings of wood that are laid horizontally and overlap one another. These boards have greater tensile strength than standard chipboard.

FIBERBOARDS

Fiberboards are made from wood that has been reduced to its basic fiber elements and reconstituted to make a stable homogeneous material. Boards of various density are produced, according to the pressure applied and the adhesive used in their manufacture.

SEE ALSO

Cabinet construction 63,65,70

Hardboards

Hardboard is a high-density fiberboard produced from wet fibers pressed at high pressure and temperature. The natural resins in the fibers are used to bond them together.

Tempered hardboard is a standard-density board that has been impregnated with resin and oil to produce a stronger material that is water- and abrasion-resistant.
Standard hardboard has only one smooth face. It is made in a wide range of thicknesses from $\frac{1}{16}$ to $\frac{1}{4}$in (1.5 to 12mm). A cheap material, it is commonly used for drawer bottoms and cabinet backs.
Duo-faced hardboard is similar to standard hardboard but has two smooth faces.
Decorative hardboard has a molded or lacquered surface.
Pegboard accepts removable hooks and fixtures.

Medium boards

Medium boards are made in a similar way to hardboard. They are produced in two grades. Low-density (LM) board, $\frac{1}{4}$ to $\frac{1}{2}$in (6 to 12mm) thick, is used for pinboard or wall paneling. High-density (HM) board is stronger and is used for interior paneling.

Medium-density fiberboard (MDF) is a fiberboard with two smooth faces manufactured by a dry process. The fibers are bonded together with a synthetic resin adhesive. It has a uniform structure and a fine texture that allows the edges and faces to be cleanly profile-machined.

This type of fiberboard can be worked like wood and can be used as a substitute for solid wood in some applications. It makes an excellent substrate for veneer and takes paint well. MDF boards are made in thicknesses of $\frac{1}{4}$ to $1\frac{1}{4}$in (6 to 32mm) and in a wide range of panel sizes.

Medium boards
1 High-density (HM) board
2 Low-density (LM) board
3 Medium-density fiberboard (MDF)
4 Oak-veneered MDF board

Hardboards
5 Standard hardboard
6 Tempered hardboard
7 Embossed hardboard
8 Decorative-faced hardboard
9 Pegboard

MAKING CURVED CUTS ON A SCROLL SAW

Cutting a curved workpiece, even one that is quite intricately shaped, is a commonplace task on a powered scroll saw. So long as you are using a blade of the right width, it is easy enough to follow a marked line freehand, always cutting on the waste side of the line to preserve the shape of the finished piece.

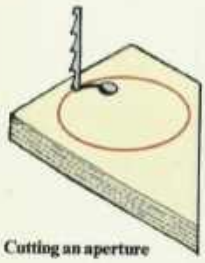
SEE ALSO

Sliding bevel	76-77
Try square	76-77
Machine-shop safety	156
Table saws	156-157
Band saws	172-173
Safety tips	179,183
Thickness planer	182-183
Hearing protectors	214

Cutting curves

Feed the work with both hands, holding it flat on the saw table while applying forward pressure into the blade. Keep your hands on either side of the blade, never directly in line with it. Be patient and feed the work slowly, allowing the blade to cut naturally. If you feel you are having to force the cut, change the dull blade for a sharp one.

While concentrating on the point of cut, it is all too easy to distort a narrow blade by unintentional sideways pressure or by twisting the work. To allow the blade to spring back to its natural position, relax fingertip pressure very slightly while continuing to maintain control over the work.



Cutting an aperture

Cutting an aperture

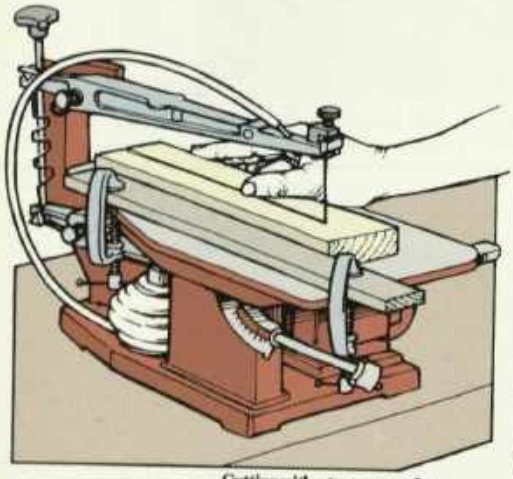
First, drill a small hole in the waste through which you can pass the blade; then, with the saw switched off, connect both ends to the saw. Switch on the saw again and follow your marked line to complete the aperture, then release the blade to remove the workpiece.

Making bevel cuts

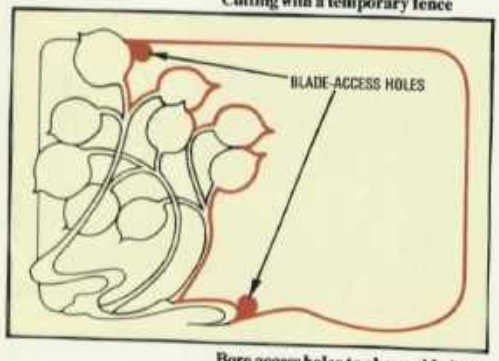
To make a bevel cut on a scroll saw, adjust the angle of the saw table, then proceed as if you were cutting a square edge, taking extra care not to distort the blade. To avoid distortion, keep the feed pressure directly in line with the cutting edge.

MAKING STRAIGHT CUTS ON A SCROLL SAW

A powered scroll saw is not especially good for making straight cuts, but you can clamp a temporary wooden fence to the table to guide the work on its intended path. As most scrollwork consists of a combination of straight and curved shapes, it is usually necessary to follow all marked lines by eye. To make a long, straight cut, following the manufacturer's instructions, turn the blade to an angle that allows you to feed the work past the saw column at the rear of the table.



Cutting with a temporary fence



Bore access holes to change blades

Combining straight and curved cuts

If the combination of straight and curved lines is such that you will need to change one blade for another, drill access holes at strategic points where the wider blade will have to be swapped for a narrow one and vice versa.

PLANERS

Having acquired a table or band saw, most woodworkers begin to think about buying a machine that will plane smooth surfaces on all four sides of a workpiece accurately. A production workshop is often equipped with two separate machines. The first is a surface planer or jointer for dressing the face side and face edge of a workpiece. The same workpiece then passes through a thickness planer that planes the remaining surfaces parallel to the face side and edge. If there is no room or need for two planers, home woodworkers often opt for a jointer/planer that combines both functions in a single machine.

Maximum planing width

Jointers are most often specified according to the widest workpiece you can plane on the machine – which is determined by the length of the cutters, called "knives," that are bolted into the revolving cutterhead. Small special-purpose jointers have short knives – 6in (150mm) or less – but the average home-workshop jointer/planer will have a maximum planing width of about 10¼in (260mm).

Cutterhead speed

The cylindrical block with its two or three balanced knives revolves at a very high speed in order to produce a clean, smooth surface. Cutterhead speed is sometimes specified in revolutions per minute, but a more telling figure is the number of cuts produced per minute by the moving cutters. A three-cutter head will produce more cuts per minute than a two-cutter head revolving at the same speed. For a two-cutter head 12,000 cuts per minute is a respectable speed.

Combined length of tables

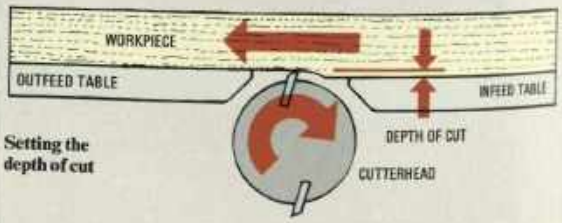
In order to be able to joint a perfectly straight edge on a workpiece, the overall length of the infeed plus outfeed tables should be as long as possible. The overall length of the average jointer is about 3ft 3in (1m).

Fence

A rigid metal fence is essential for jointing true square or beveled edges on a workpiece. All fences can be tilted to any angle from 90 to 45 degrees to the tables. It is convenient if the fence automatically comes to a stop at both extremes, but check the settings with a try square or sliding bevel.

Maximum depth of cut

The cutterhead is situated between two independently adjustable cast-metal tables. The height of the table to the rear of the cutterhead – the outfeed table – should be adjusted so it is level with the top of the circle described by the revolving cutters. The table in front of the cutterhead – the infeed table – is lowered to produce the required depth of cut, up to a maximum of about ⅛in (3mm). A very shallow $\frac{1}{32}$in (1mm) cut will produce a superior finish; but for speed, make two or three deeper cuts followed by one or more finishing cuts. Depth of cut is indicated by a scale next to the infeed table.



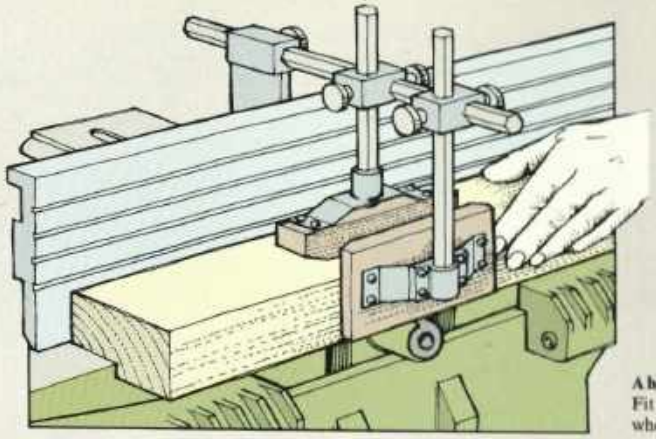
Setting the depth of cut

Cutterhead guard
A jointer's revolving cutters are capable of severing a fingertip in a fraction of a second – so never operate the machine without the appropriate guard.

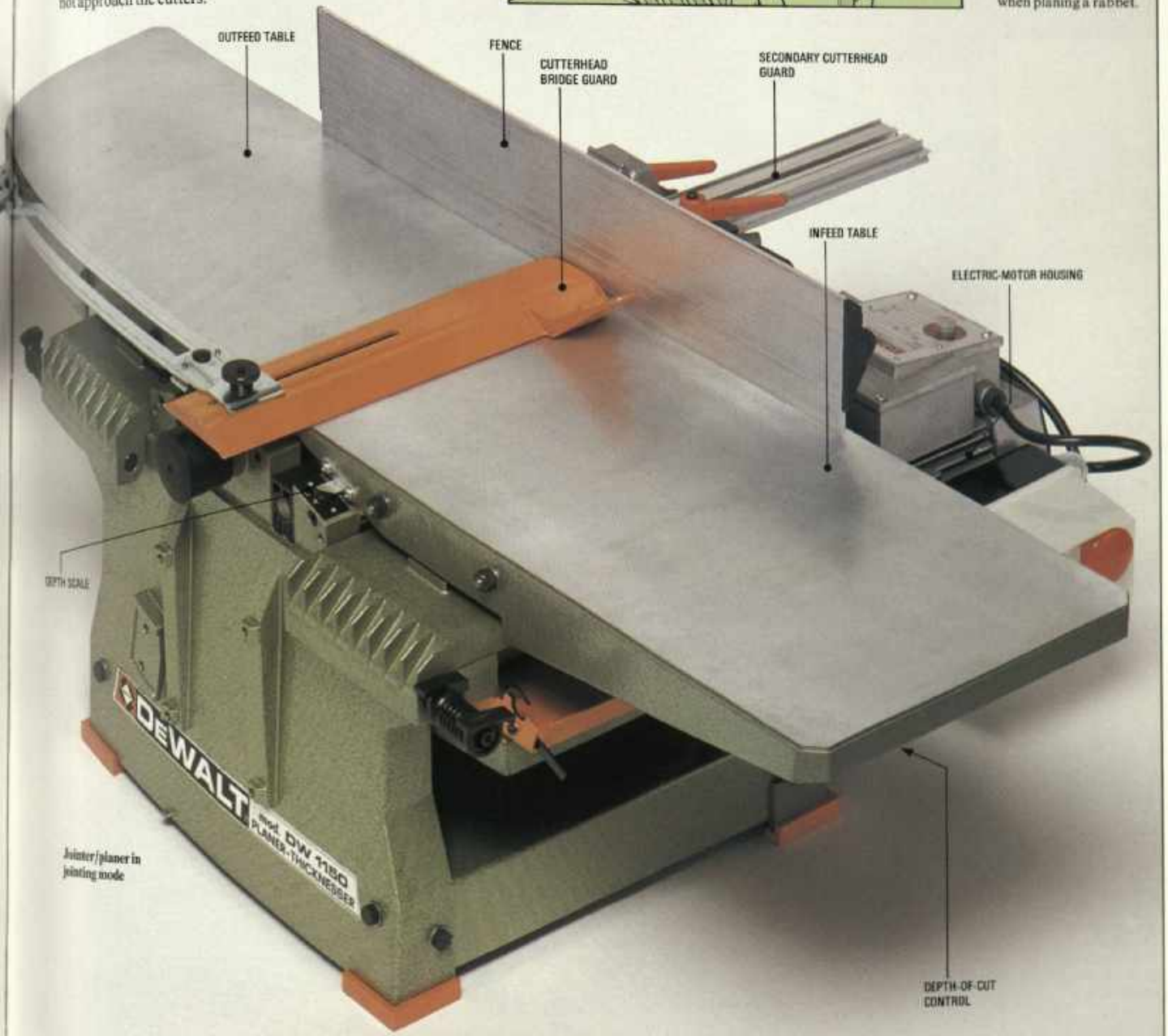
A bridge guard that is adjustable in height and that can be slid across the entire width of the cutterhead is the ideal form of protection. Some jointers are made with spring-loaded bridge guards that are lifted or pushed aside by the work as it is passed over the cutterhead. This type of guard is superior to the simpler version that merely swings aside to expose the cutters.

In addition, there should be a guard behind the fence that is automatically drawn across the cutterhead as the fence is adjusted sideways.

You should never attempt to rabbet a workpiece without a vertical/horizontal hold-down guard, so your hands need not approach the cutters.



A hold-down guard
Fit this type of guard when planing a rabbet.



Jointer/planer in jointing mode

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Machine-shop safety	156
Pawls	165
Direction of feed	180
Surface planer	180-181
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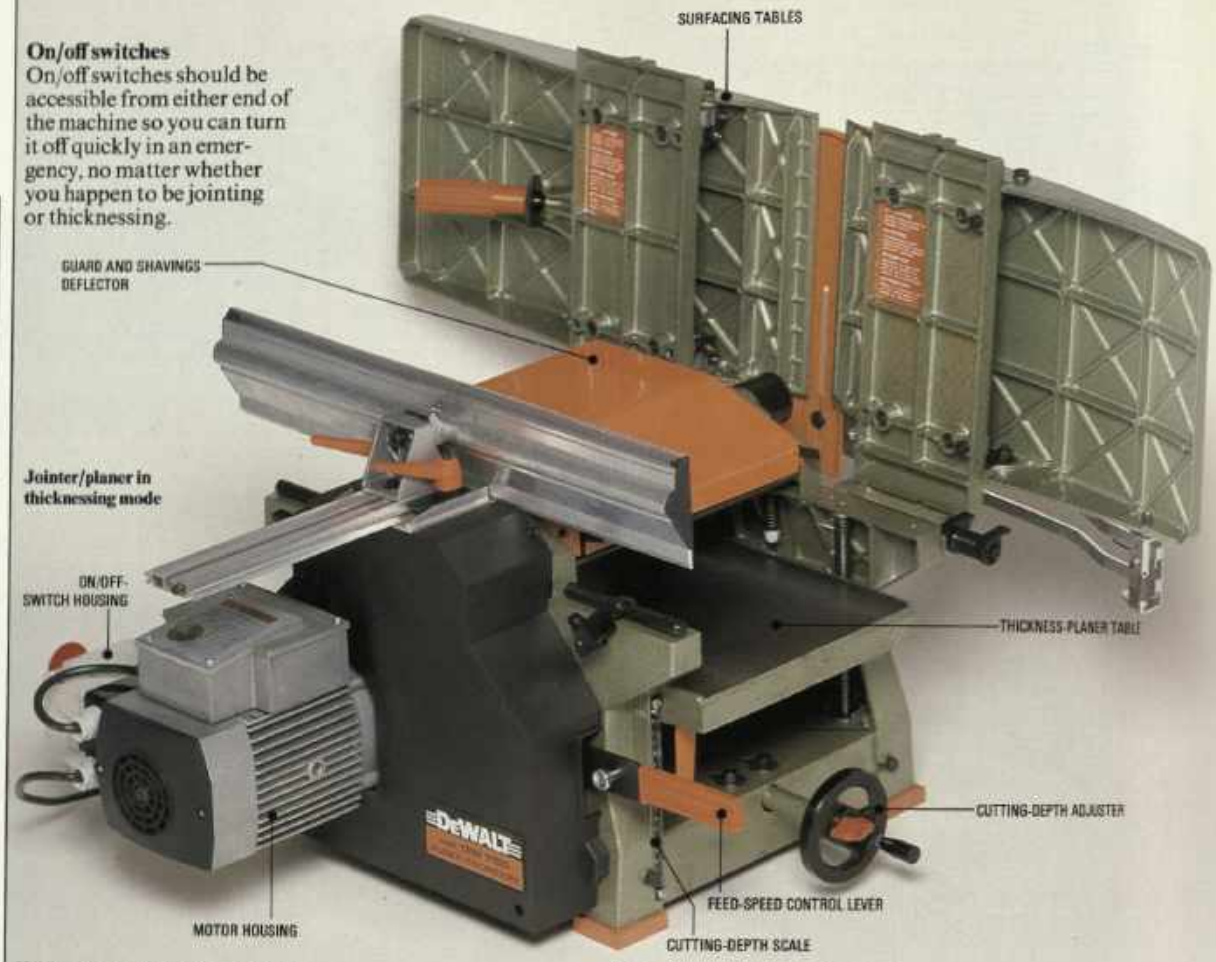
Cellulose lacquer	290

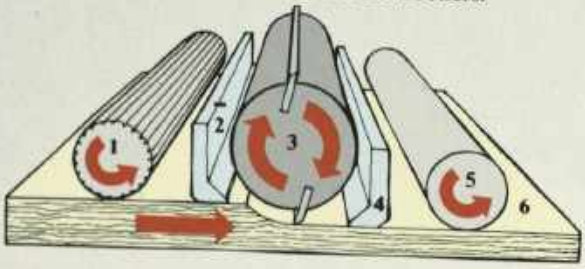
On/off switches
On/off switches should be accessible from either end of the machine so you can turn it off quickly in an emergency, no matter whether you happen to be jointing or thicknessing.



Jointer/planer in thicknessing mode

Width of thickness-planer table
The average thickness-planer table is 10in (250mm) wide. Never attempt to plane a workpiece that is shorter than the width of the table. If a piece of wood is able to turn sideways, it may be splintered by the feed rollers and cutters, and pieces can be thrown out of the planer with considerable force.

Feed rollers
A planer is equipped with two motor-driven spring-loaded feed rollers that pass the workpiece under the revolving cutterhead and out the other end of the machine. The infeed roller, usually a horizontally ribbed steel roller, is situated in front of the cutterhead and provides the main driving force. The outfeed roller, which is situated behind the cutterhead, is smooth – so as not to mark the planed surface – and exerts less pressure on the work. When taking a very shallow cut, the parallel bruising left by a ribbed roller is sometimes detectable on the planed surface. For this reason, some planers are made with rubber-covered drive rollers.



Planer feed rollers
1 Infeed roller
2 Chip breaker
3 Cutterhead
4 Pressure bar
5 Outfeed roller
6 Workpiece

Maximum thicknessing depth
When a workpiece is passed through a planer, it travels on a bed situated beneath the same cutterhead used for jointing. The planer table on the average home-workshop machine can be raised or lowered to accommodate any workpiece up to a maximum thickness of 6 to 7in (160 to 180mm). Even though the planer is power driven, never attempt to take more than $\frac{1}{8}$in (3mm) in one pass.

Electric motors
A small 375W ($\frac{1}{2}$hp) electric motor is powerful enough for a special-purpose jointer. However, on a thickness planer the motor is used to drive the feed rollers and cutterhead simultaneously, so a larger 1.5 to 2.2kW (2 to 3hp) motor is required. On some models, the drive rollers can be disconnected from the motor so that its entire output is available for jointing.

Planer feed rate
Because an amateur woodworker is not primarily concerned with a fast output of work, he or she is more likely to be attracted by a planer that produces a good finish at the expense of speed – since a slow feed rate combined with a high cutterhead speed produces the best finish. Many thickness planers are therefore designed to feed the work at the relatively slow speed of about 16ft (5m) per minute. However, you can buy a planer with a feed rate of 29ft (9m) per minute, which can be increased to 36ft (11m) per minute. As a general rule, feed hardwoods slowly but increase the feed rate for softwoods.

Anti-kickback device
If for some reason the drive rollers lose their grip on a workpiece, it may be thrown out of the machine by the cutterhead and a serious accident can occur if you are feeding the work at the time. To prevent this, a row of pointed metal teeth or "pawls" hang in front of the infeed roller. As the work travels under them, the pawls lift to allow free passage. Should the work begin to travel backward, the pointed pawls catch in the wood surface and restrict its movement.

Dust collection
Without a dust collector, shavings are dumped onto the tables above and below the cutterhead, impairing the efficiency and accuracy of the machine. Consequently, you have to stop the planer regularly to clear the accumulated debris. A hose attachment leading to a portable vacuum solves the problem.

USING A JOINTER/PLANER SAFELY

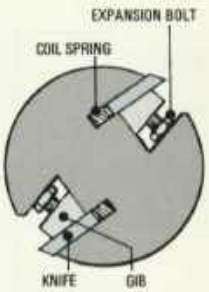
Always operate a jointer/planer confidently but with extreme caution. An accident can happen so quickly that even the fastest reflexes will not save you from injury. It is therefore essential to cultivate a safe method of working and always observe general machine-shop safety procedures.

- Follow the manufacturer's instructions for installing knives, and always complete the procedure before you leave the machine. If you are distracted and forget to secure a knife, a serious accident could result when you switch on the machine.
- Inspect the machine before you switch it on to make sure nothing is likely to foul the cutterhead.
- Never use a jointer without a properly adjusted guard in position.
- Use a push block to feed a thin workpiece over the cutters. Never attempt to joint a piece of wood less than ¼in (6mm) thick.
- Don't attempt to joint a workpiece that is too short to be held firmly in both hands.
- Never trail your fingers or thumb behind a workpiece.
- Always feed work against the direction of rotation of the cutterhead. When jointing, pass the work from infeed to outfeed table. Feed from the opposite end of the machine when thicknessing.
- Feed one workpiece at a time through a thickness planer. The feed-roller pressure may not be consistent across a number of pieces, and one of them could be thrown back by the cutterhead.
- Don't try to force a workpiece through a thickness planer. Let the feed rollers work at their intended rate.
- When planing a workpiece of uneven thickness, set the depth of cut to handle the thickest section first, then gradually raise the planer table between passes until you are cutting the full length of the board.
- Don't feed work that is shorter than the width of the planer table or shorter than the distance between the feed rollers.
- When planing long workpieces, either have an assistant take the weight as they come off the machine or set up a roller stand or sawhorses to support the work.
- Never put your hands into a thickness planer to retrieve a workpiece or clear away shavings. Use a long push stick instead, to extend your reach.

JOINTER AND PLANER KNIVES

A few jointers and planers are made with double-edge disposable cutters similar to those used in portable power jointers. However, the majority of machines are fitted with two or three single-edge cutters or "knives" that need to be honed and sharpened at regular intervals.

Types of cutter
Jointers and planers for the home-workshop market are supplied with high-speed-steel knives that are perfectly adequate unless you expect to plane a lot of chipboard or "gritty" woods like teak. When planing these materials, follow production-workshop practice and fit the more expensive tungsten-carbide knives, which will hold a sharp edge much longer but must, when the time comes, be sent to a professional for sharpening. Even high-speed-steel knives are sent for regrinding, but they can be honed in the meantime by running an oilstone along the cutting edges.



A typical cutterhead

Fitting knives
It is important to follow the manufacturer's instructions for fitting knives. However, in principle, each knife fits into a slot in the cylindrical cutterhead. In some cases the knife rests on springs at the bottom of the slot, and height adjustment is simply a matter of holding the knife down against their compression. The knife is normally secured with a wedge-shaped gib held tight by adjusting expansion bolts. Always double-check that the knives are tight before you switch on the machine.

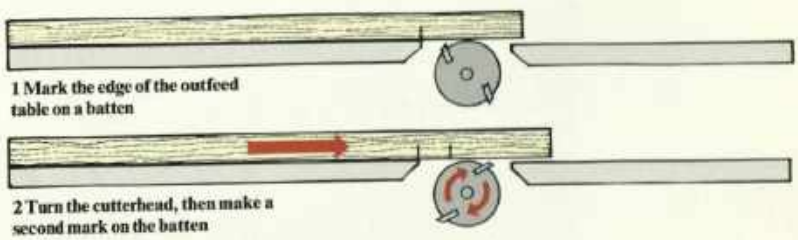
Adjusting knives
Each knife must project from the head by exactly the same amount if it is to do its fair share of the work. If one knife is set higher than another, it will do all the planing and a rougher surface will result. It is possible to buy special equipment for gauging knife setting, but in a home workshop, a straight batten is good enough. Always unplug the machine before making adjustments to the knives.

Adjust all the knives by eye until they appear to project the required amount. Lower the outfeed table slightly, then rest the wooden batten on it overhanging one end of the cutterhead. Mark the edge of the outfeed table on the batten **(1)**. Turn the cutterhead slowly by hand, allowing the knife to lift the batten and carry it forward, then mark the edge of the batten again **(2)**.

Move the batten to the other end of the cutterhead, aligning the first mark with the edge of the table. Turn the cutterhead again. The same knife should move the batten forward by exactly the same amount. If the second mark does not align with the table edge, adjust the height of the knife at that end until it does.

Tighten the gib bolts, then repeat the gauging process at each end to make sure that clamping has not altered the setting. Turn the cutterhead and set each knife in the same way. Finally, raise the outfeed table until each knife just scrapes the underside of the batten.

- **Cleaning the cutterhead** Before you fit new or reground knives, clean wood resin from the cutterhead slots and gibs with a solvent such as lacquer thinner or mineral spirits.


1 Mark the edge of the outfeed table on a batten

2 Turn the cutterhead, then make a second mark on the batten

BUTT JOINTS

The butt joint is the simplest form of joint where one member meets another with no interlocking elements cut into the parts. It is not a strong joint and is often reinforced in some way. Right-angled joints are used in the construction of light frames and small boxes. The joining ends may be square-cut or mitered.

SEE ALSO

Measuring and marking tools	76-79
Planes	88,96
Planing end grain	93
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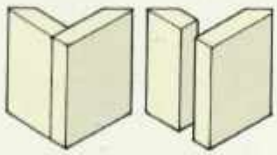
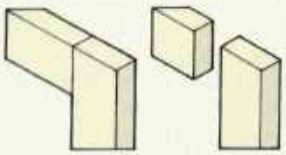




SQUARE-ENDED BUTT JOINT

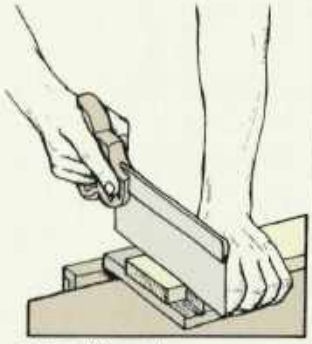
Butt joints for boxes are made with the end of one member glued to the inside face of the other. For frames, the end is glued to the edge. It is essential for the surfaces to be flat and the ends square.

Cutting the joint

Mark the length of the parts and square a shoulder line all around with a marking knife. Using a bench hook to hold the work, saw off the waste clear of the line **(1)**.

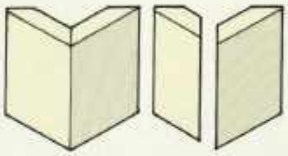
Trim the end grain with a plane to provide the best surface for gluing. Use a shooting board to guide the plane, in order to ensure a square end **(2)**.

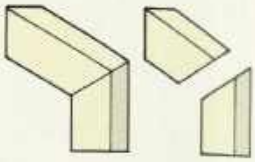
Apply glue to the joint and clamp the parts together. Make sure the components are aligned properly, as the joint has no means of locating itself.



1 Saw off the waste

2 Shoot the ends square



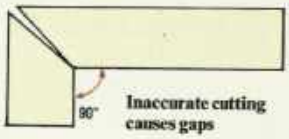


MITERED BUTT JOINT

A miter halves the angle between the parts being joined. In most instances, joints are made at 90 degrees, so the common miter is set at 45 degrees. End grain to end grain does not offer a good gluing surface; but the miter's larger area, compared with the square butt joint, does compensate to some degree. The miter is usually reinforced with nails or tongues.

The importance of accuracy

Miters need to be cut accurately, as gaps will show on the inside or outside if the miter is not exactly half the angle. Use well-seasoned wood, as a gap will open up on the inside of the angle if the wood shrinks after cutting the joint.



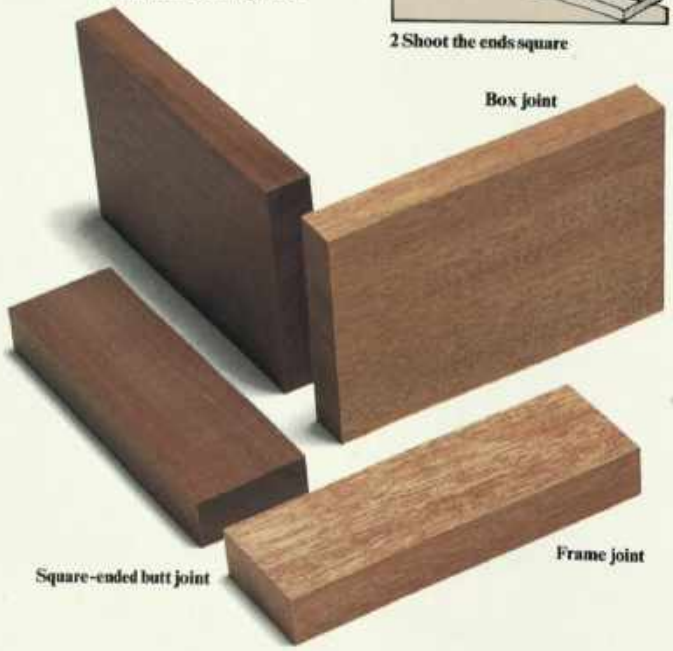
Inaccurate cutting causes gaps

Shrinkage can cause inside gap

Cutting the joint

Mark the cutting lines with a knife and miter square on the face or edge. Square the lines onto the adjacent faces from the miter angle. Cut off the waste with a tenon saw. To guarantee greater accuracy, use a miter box **(1)**, particularly if cutting decorative moldings, which are more difficult to mark with cutting lines.

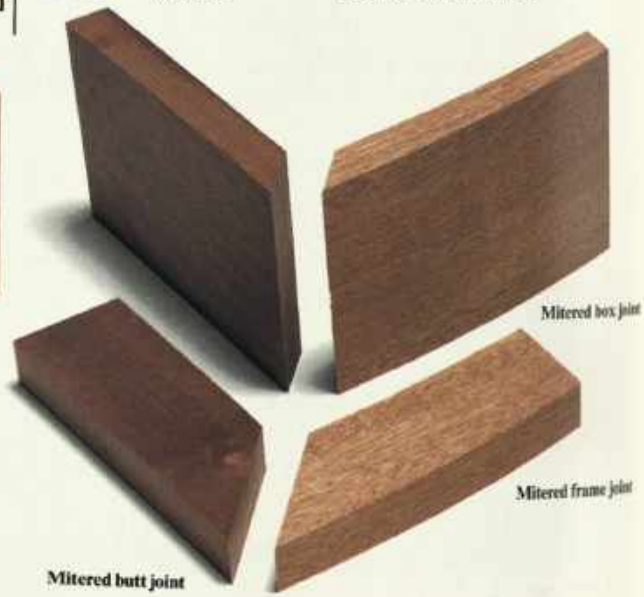
Trim the cut end with a plane and miter shooting board **(2)**. For wide boards, use a miter shooting block **(3)**. If this is not available, set the work in a vise with a piece of scrap wood at the back edge to prevent break-out **(4)**.



Box joint

Square-ended butt joint

Frame joint



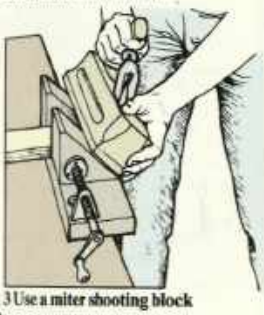
Mitered box joint

Mitered frame joint

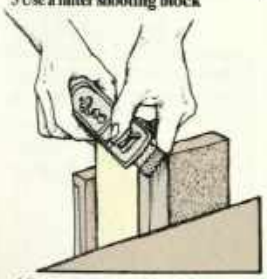
Mitered butt joint

1 Cut off the waste

2 Plane the ends smooth



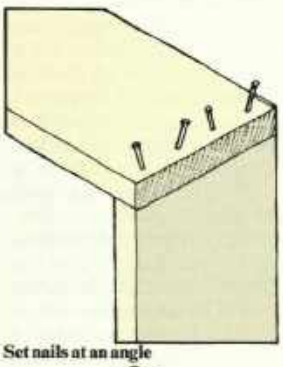
3 Use a miter shooting block



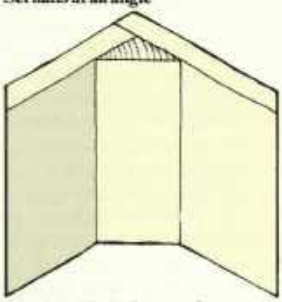
4 Or use scrap-wood backing

Reinforcing a square-ended butt joint

As the end grain does not glue well, additional reinforcement is usually required. You can use fine finishing nails or blocks glued into the angle. Drive the nails into the joint dovetail-fashion to provide additional mechanical strength. In some cases the nails can be used in place of clamps when gluing up. If using glued-block reinforcement, rub-joint them into the angle and leave the glue to set.



Set nails at an angle



Rub-joint blocks into angle

REINFORCING A MITERED BUTT JOINT

The easiest way to reinforce a mitered joint is to glue it first and add the reinforcement when set. Use a miter clamp or a web clamp for gluing up.

Using nails

For nailing, use brads or fine nails, depending on the size of the joint. Sink the nail heads and disguise the holes, using matching colored filler.

Using splines

For small joints, veneer or plywood splines can be set in sawcuts made across the corner. Make the cuts perpendicular, or angled for additional strength. Glue the splines into the sawcuts and trim them flush when set. Use splines of contrasting wood for a decorative effect.

Using a loose tongue

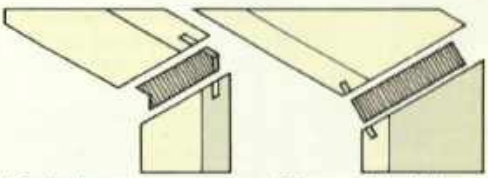
For larger miters, a loose tongue or key can be fitted. Set a mortise gauge to the thickness of the tongue, which can be solid wood or plywood and about one-third the thickness of the frame material. Mark the gauge lines on the edges and centered on the thickness. Square lines across the end of the gauged lines the same distance from the corner on each edge.

Set the joint in a vise with the shoulder line vertical. Carefully saw down each line and chop out the waste with a chisel, working from both sides toward the middle. Glue the loose tongue and plane it flush when set. If you are using a solid-wood loose tongue, its grain must run across the corner.

Integral reinforcing

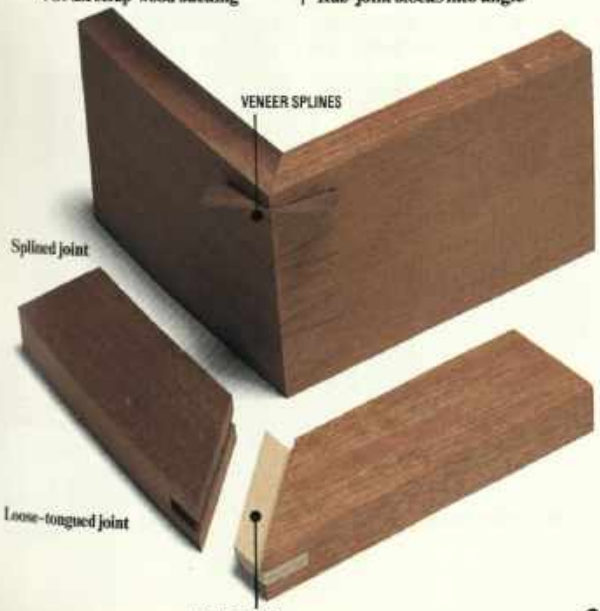
A loose tongue is also used to reinforce a miter before the joint is glued together. This type is more easily cut by machine, but can be made by hand.

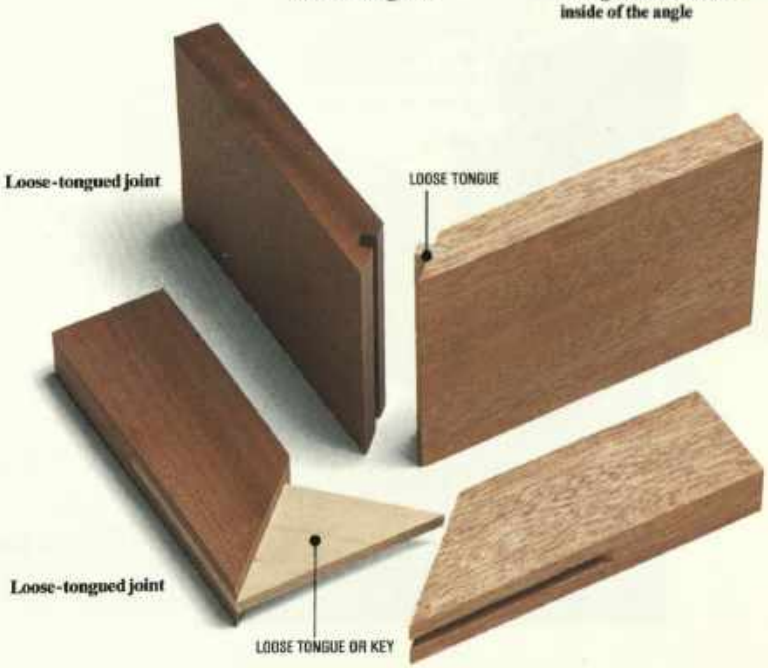
Make the tongue from $\frac{1}{8}$in (3mm) plywood about $\frac{1}{2}$in (12mm) wide or use solid wood, with the grain running across the width. Cut matching grooves by hand with a saw and chisel or with a plow plane. Center the groove when the tongue runs with the miter **(1)**. When cutting across the miter, set the groove closer to the inside of the angle to avoid leaving weak short grain **(2)**.



1 Center the groove

2 Set groove close to the inside of the angle





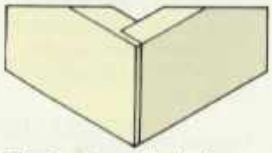
RABBET JOINTS

The rabbet joint is a straightforward corner joint used for simple box and cabinet construction. Also known as a lap joint, the plain end of one part is set in a rabbet cut in the other. It is the remaining wood left by the rabbet that forms the lap and covers the end grain of the other member.

SEE ALSO

Measuring and marking tools	78-79
Backsaws	83
Shoulder planes	92,93
Chisels	98,101
Routers	142,146
Table saws	162
Radial-arm saws	169
Adhesives	302-303

SIMPLE RABBET JOINT



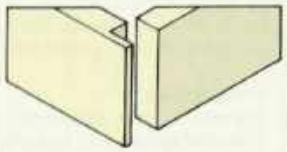
This is not a particularly strong joint and needs pinning, but it is better than a butt joint in strength and appearance.

Cutting the joint

Cut the wood to length. Set a marking gauge to one-quarter or one-third the thickness of the rabbeted member. Scribe a line on the end and over the top and bottom edges, working from the face side **(1)**. Reset the gauge to the thickness of the butting member. Run the gauge against the end of the rabbet member to scribe a line on the back face and edges **(2)**. Mark the waste with a pencil.

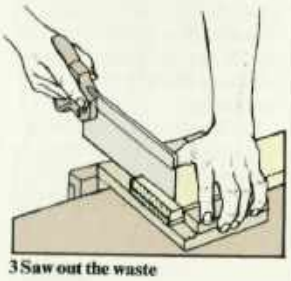
Set the rabbet member in the vise. Saw down the lap-gauge line to the shoulder line. Hold the work on a bench hook and cut across the shoulder line to remove the waste **(3)**. Trim the rabbet with a shoulder plane if necessary.

Apply glue to the joining parts, clamp together and secure with pins driven through the side member.



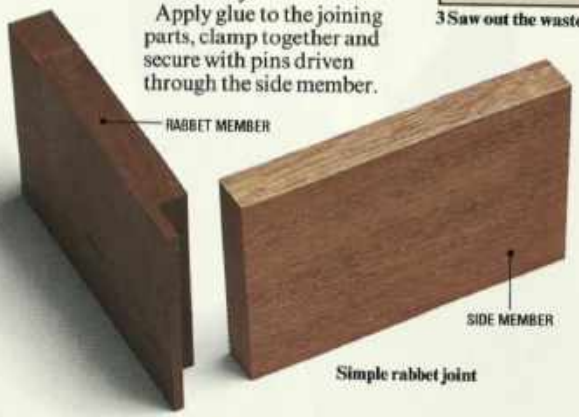
1 Mark the rabbet-gauge line

2 Mark the shoulder line



3 Saw out the waste

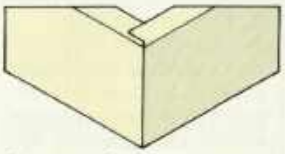
- **Scarf joint**
  A form of lap and miter joint in one, this is used to join wood end to end. A long shallow taper in each part gives a large gluing area. Saw or plane the length of the taper to at least four times the thickness of the wood.



Simple rabbet joint

Scarf joint

MITERED RABBET JOINT



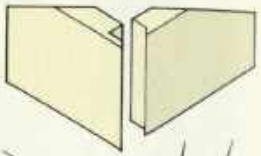
The mitered rabbet is neater than the simple rabbet, but is more difficult to cut.

Cutting the joint

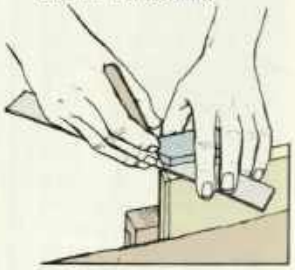
Mark and cut the rabbet as described (see left). Mark a 45-degree miter on the edges of the rabbet **(1)**. Square a line across the inside of the rabbet. Plane off the waste down to the miter line.

Using the marking gauge at the same setting, scribe a shoulder line on the inside and edges of the butting member, working from the end. Then, with the stock against the outside face, scribe a line across the end and over the edges to meet the shoulder line. Mark a miter on each edge from the outside face to the point where the two gauge lines meet each other **(2)**.

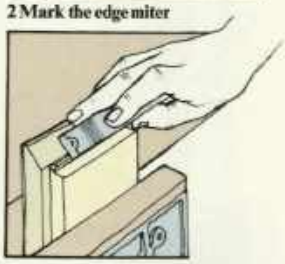
Hold the work flat on a bench hook and saw down the shoulder line to the miter. Set it upright in a vise and saw down the gauge line to remove the waste. Reset the work in the vise and, using a shoulder plane, carefully shape the miter **(3)**.



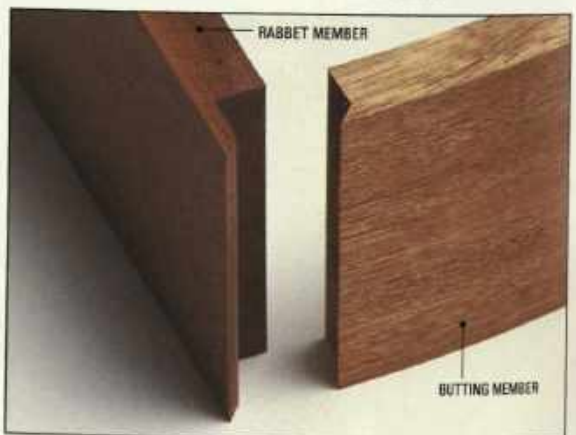
1 Mark the rabbet miter



2 Mark the edge miter



3 Plane the miter

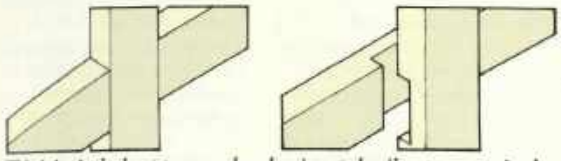


Detail of mitered rabbet joint

LAP JOINTS

Lap joints are usually cut in components of equal thickness and have half the thickness of the wood cut from each piece. They are relatively simple to cut and are used in frame construction where one member must cross or meet another in the same plane. The joint can be cut by hand with a saw and chisel or machine-cut. The methods shown here are for hand-cutting different forms of the basic joint.

CROSS-LAP JOINT



This joint is the best to use when horizontal rails cross vertical members of a frame, such as the divisions in a cabinet front or the glazing bars of a door or window.

Marking out the joint

It is conventional practice for the divider to run through, although the joint is equally strong either way.

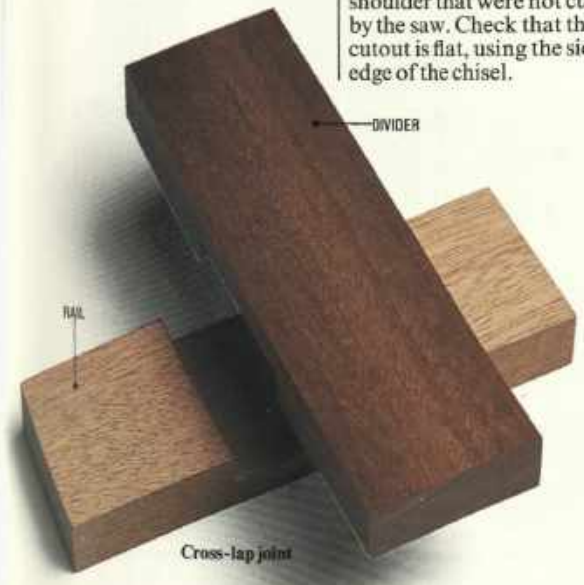
Mark the width of the divider on the rail **(1)**. Using a try square and marking knife, square lines across the face of the rail and carry them over and halfway down each edge **(2)**. Turn the wood over and use the same procedure to mark the width of the rail on the back face of the divider.

Set a marking gauge to half the thickness of the wood and scribe a line on the edges between the marked lines, working from the face side of both parts **(3)**. Mark the waste.

Cutting the joint

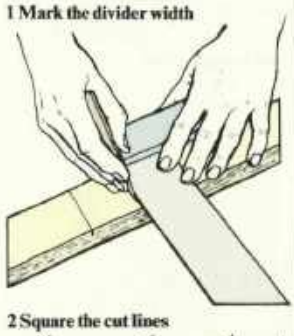
With the aid of a bench hook, saw along the shoulder line to the depth of the gauged line. Be sure to keep just inside the waste side of the line, as a loose joint is unsightly and weak. Make one or two extra sawcuts evenly spaced across the waste to make chiseling out the waste easier **(4)**.

Set the work in a vise. Using a suitably sized chisel and a mallet, cut away the waste wood. Work toward the middle with the chisel held at a slight upward angle **(5)**. Turn the wood around to cut from the other side. With most of the wood removed, pare away the remaining raised portion in the middle. Use the chisel vertically to sever any wood fibers along the base of the shoulder that were not cut by the saw. Check that the cutout is flat, using the side edge of the chisel.

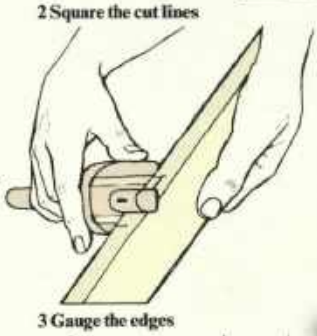


Cross-lap joint

1 Mark the divider width

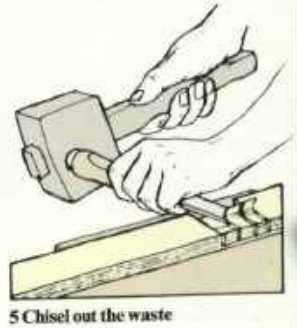


2 Square the cut lines



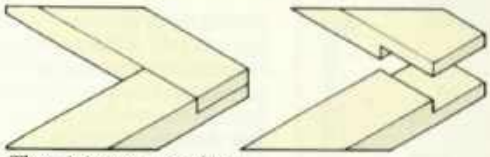
3 Gauge the edges

4 Saw across the waste



5 Chisel out the waste

CORNER-LAP JOINTS

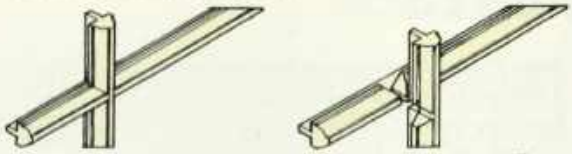


These joints are simple to cut, but rely on the glue for their strength and may require extra support from screws or dowels. The mitered corner lap is a refined version, but is not as strong because of the reduced gluing area.

Corner-lap joint

Mitered corner-lap joint

GLAZING-BAR LAP JOINT



The cutting of a lap joint in a molded glazing bar is basically the same as that used for a cross-lap joint, but there is the added complication of the molded section.

SEE ALSO

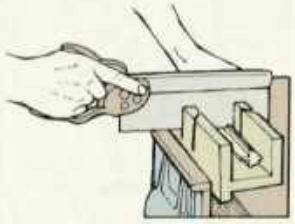
Measuring and marking tools	76-79
Backsaws	83
Routers	146
Table saws	162
Radial-arm saws	169
Miter box	213
Dovetail angles	239

Cutting the joint

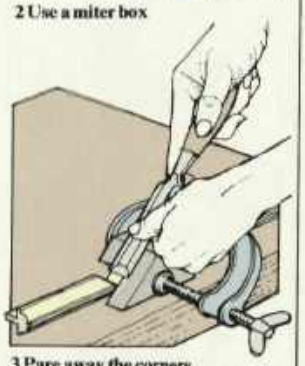
Cut away the molding on each side of the joint after marking its position. Cut down to the depth of the top face of the molding. The width of the cutout is the same as the top face **(1)**. As it is difficult to mark a line over the contoured surface, use a miter box to make the sawcut **(2)**.

Make a 45-degree miter block for trimming the molding. Clamp the block to the work and pare away the corners of the molding with a chisel **(3)**.

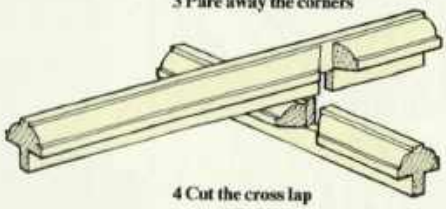
Now cut the lap joint in the remaining section of each part. The depth of the cutout in each should be level with the line of the molding rabbet **(4)**.



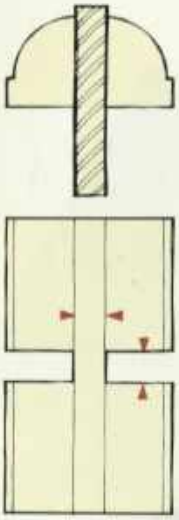
2 Use a miter box



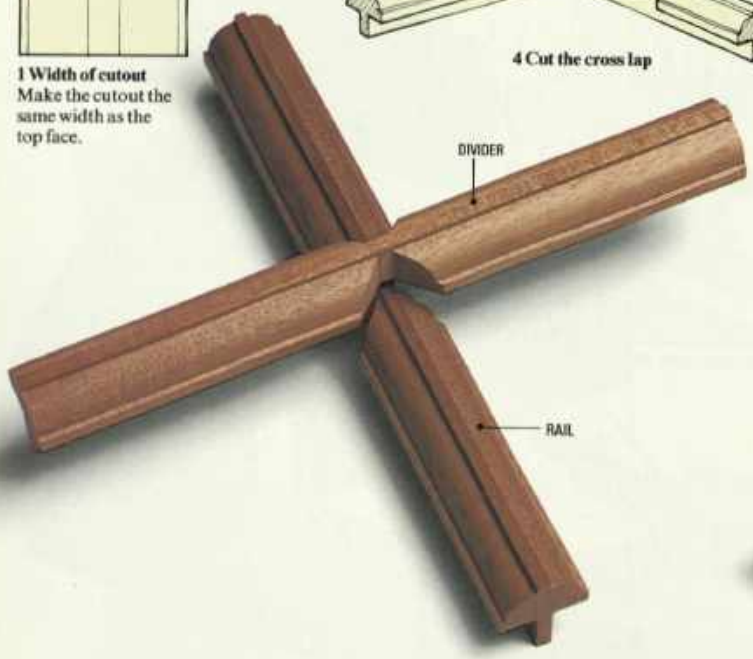
3 Pare away the corners



4 Cut the cross lap

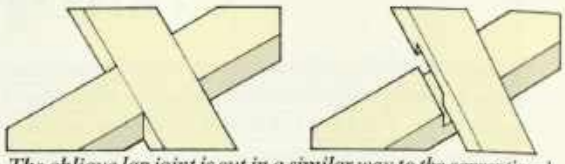


1 Width of cutout
Make the cutout the same width as the top face.



Glazing-bar lap joint

OBLIQUE LAP JOINT



The oblique lap joint is cut in a similar way to the conventional cross-lap joint, but the cutouts are set at an angle. The main difference is the marking out of the shoulder.

Marking out the joint

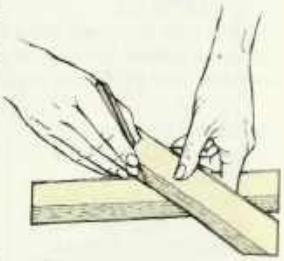
Making a 45-degree angle is very simple when using a miter square. For any other angle, it is necessary to use a sliding bevel set with the aid of a protractor or by taking the setting from an accurate drawing.

Mark one angled shoulder line on the face side of the bottom member. Place the top member on the line and mark its width **(1)**. Scribe the second shoulder line on the mark. Square the lines halfway down each edge and mark a line between them with a gauge set to half the thickness of the wood.

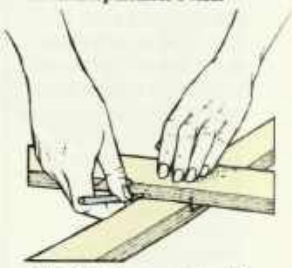
Place the top member, face side up, in position and mark the width of the bottom piece on both its edges **(2)**. Mark the cutout on the underside with the bevel or square.

Cutting the joint

Saw and chisel out the waste from both parts as for a cross lap, but working at the marked angle.



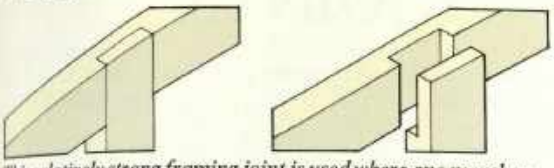
1 Mark top member's width



2 Mark bottom member's width

Oblique lap joint

"T" LAP JOINT

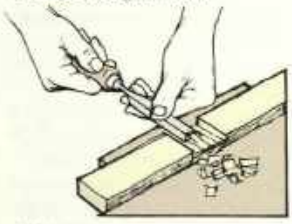


This relatively strong framing joint is used where one member intersects the other, finishing flush on the outside edge.

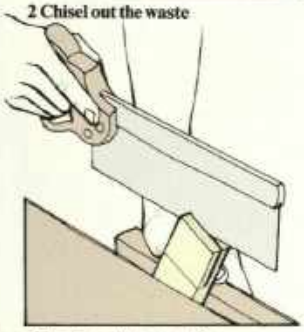
Marking out the joint
After marking the cutout on the cross member of the "T" as described for cross laps, cut the end of the upright member square and mark the width of the cross member on its underside. Square the line onto the edges and run a gauge line along each edge and along the end **(1)**.

1 Gauge the edges and end

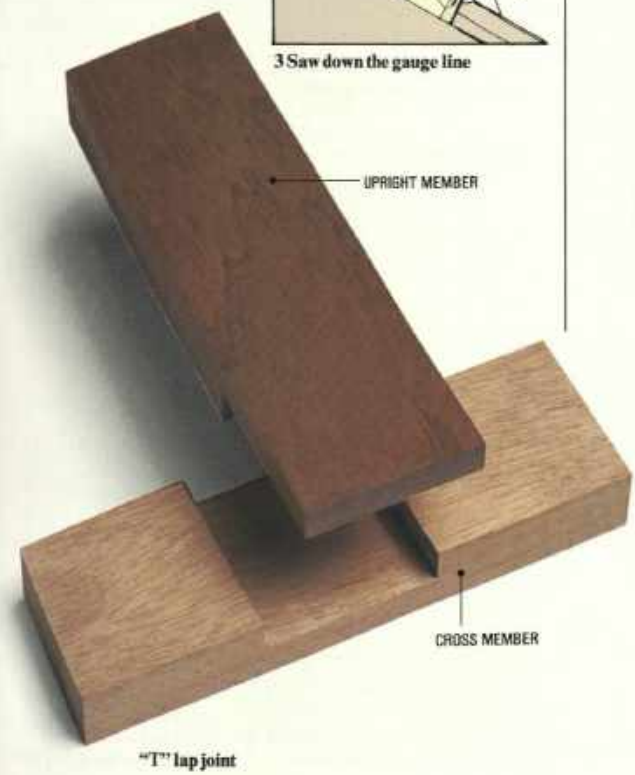
Cutting the joint
Saw and chisel out the waste from the cross member **(2)**. Saw down first the gauged line on the waste side and then the shoulder line to remove the waste from the upright member **(3)**.



2 Chisel out the waste

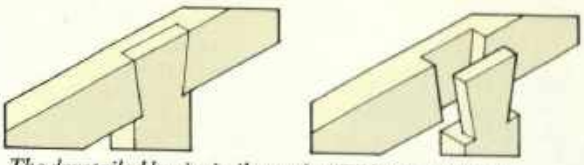


3 Saw down the gauge line



"T" lap joint

DOVETAILED LAP JOINT

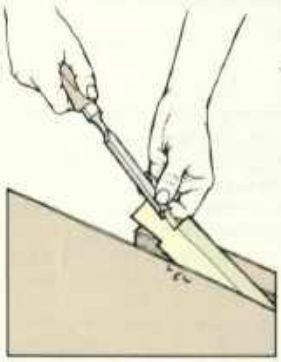


The dovetailed lap is similar to the "T" lap joint, but is stronger, as it can resist pulling forces better.

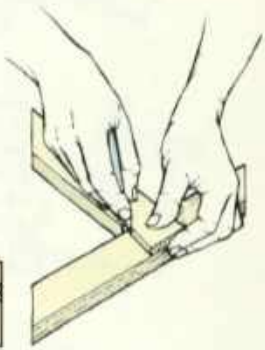
Marking and cutting the joint
The upright member forming the tail piece is cut first. Mark out and cut the end lap, as described for the "T" lap. Mark out the slope of the dovetail with a template **(1)** or set it out with a ruler. Saw or pare away the waste depending on the size of the wood **(2)**.

Lay the dovetailed end on the cross member and mark its shape on the face side **(3)**. Square the lines down the edges and gauge the depth line between them. Then saw and chisel out the waste.

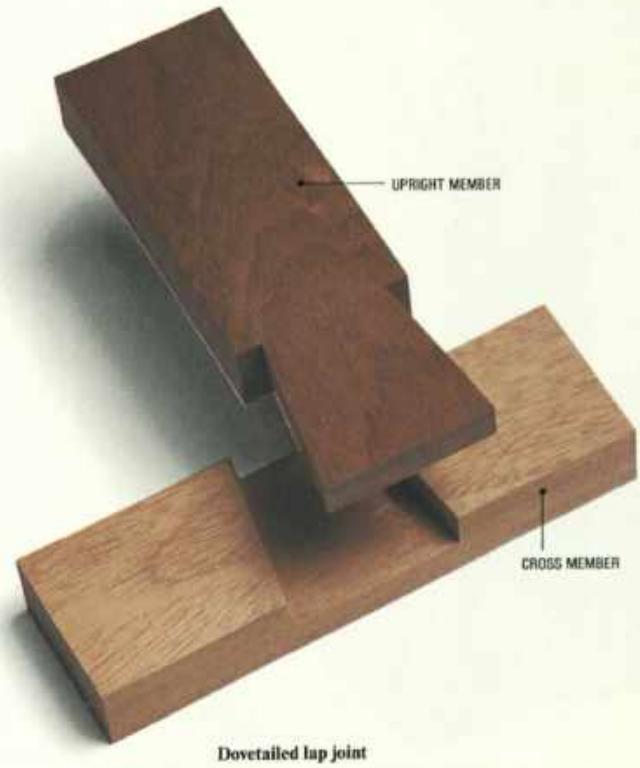
1 Mark the dovetail slope



2 Pare away the waste



3 Draw around the shape



Dovetailed lap joint