Practical Woodwork for Laboratory Technicians

BY

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Preface

MANY years of work with laboratory technicians of both sexes have shown a need for a book covering the City and Guilds Laboratory Technician Course. It is hoped that it will be particularly valuable to external students unable to attend specific courses of instruction. The book is intended also to be a help and guide to established technicians and scientific workers in maintaining laboratories and workshops and in the production of apparatus for demonstration and research.

The book, despite its title, should have an appeal to the amateur woodworker and the do-it-yourself enthusiast, and would be useful in many types of schools.

With a view to the introduction of metrication, metric units have been used throughout the book, but because of the uncertainty that exists in various branches of the trade, and of the obvious transitional period that must occur, equivalent imperial measurements have been included. There may well be many subsequent changes to the measurements and sizes given, but these should not detract from the value of the book.

I would like to express my appreciation to my wife for her patience and help in the preparation of the manuscript.

Chapter 1

Timber and Allied Materials

THE modern woodworker is concerned with many materials, both natural and man-made, and of these timber is of greatest importance. Timber is that product of trees which can be used for any woodwork construction. It is divided into two main classes, softwoods and hardwoods, the division being botanical and not related to the actual hardness of the timber, although generally speaking the division is true. Softwoods come from conifers, which are needle leaf cone bearing trees, while on the other hand hardwoods come from deciduous or broad leaf trees. As an example of the anomaly of the division, balsa wood, which is the softest and lightest wood known, is a hardwood, while pitch pine, which is extremely hard, is a softwood.

Seasoning

Trees are normally felled when they contain the least amount of moisture, but in order to make the timber more serviceable, further reduction of the moisture content is carried out in the process of seasoning. Complete removal of the moisture will make the timber too brittle and liable to collapse, similar to the state of dry rot, whereas seasoning strengthens the timber, leaves it in a more stable state and makes it less prone to attack by fungus. The removal of the moisture is done by natural air drying, or by artificial kiln drying. After trees have been felled, the logs are brought to the saw mill, where they are sawn into suitable sized boards and stacked in open-sided sheds, the boards being separated at intervals by skids or stickers (Fig. 1.1). This allows complete circulation of air currents around the boards and yet they are protected from rain and snow. Because the greatest amount of evaporation occurs through the ends of the boards, they are often sealed with paint, tar or other sealing compound to prevent too rapid evaporation. This seasoning process will take up to two years, depending on the kind of timber and the size of the boards.

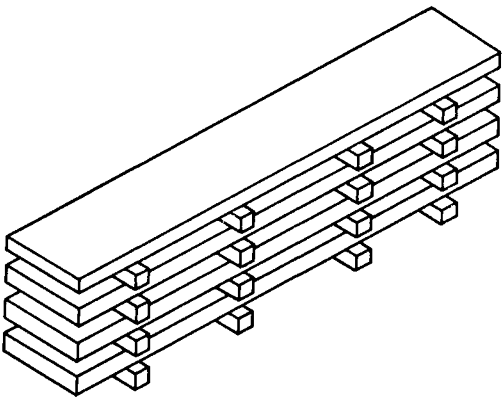


FIG. 1.1. Method of stacking timber for seasoning.

Kiln drying consists of loading separated boards on to trolleys and putting them into large kilns. Inside the kilns, heaters turn water into steam jets to cause a continuous circulation of steam around the boards for up to two weeks. The moisture content is again reduced, but the process is much more rapid and maintains a standard for every similar batch of timber. Wood, because of its fibrous nature, is rather like a sponge, in that it can give out and take in moisture so that there is continuous movement within the timber. The moisture content of the wood is an important factor and timber is often specified as having a given percentage moisture content, so that for external use the content may be as high as 25%, or if for use in central heated conditions, the content may be as low as 8%. Doors and windows which are not completely sealed against further loss or gain of moisture will stick during wet weather or will show gaps during dry weather. It is best to wait until the wood has dried to its proper size before resealing against further moisture change.

Storage

Obviously timber which is being stored must be stacked properly so as to allow for equal evaporation on all surfaces. To illustrate this, if a piece of paper is wetted on one side it will curl in such a way that the wet side is on the outside. Again, a piece of paper held over a flame will also curl, but this time with the heated side on the inside. If a piece of veneer is similarly treated, then the same reactions will be observed. Likewise timber will curl or warp accordingly as one side is allowed to dry more than the other. Warping can often be cured by damping the hollow or concave side and allowing the opposite side to dry. This is also the reason why veneered timber should be counter veneered, for as the veneer dries out it shrinks and in doing so must pull the timber into a curved shape. Timber, therefore, must be stored so that the moisture from all surfaces has an equal chance of evaporating. Note that although boards leaning against a wall will have these conditions, they will tend to bow under their own weight.

Faults in Timber

Timber can develop many faults through bad seasoning, or by too rapid a loss of moisture. Flat or plain sawing, which means the timber is cut tangentially to the annual rings, produces boards which tend to shrink away from the heart, so that floor boards for instance should be laid with the heart side to the joists. Square timber tends to become rhomboidal and all ready planed timbers and mouldings should be checked for squareness. Unequal shrinkage causes end splits, heart shakes, star shakes, surface shakes and cupping and examples of these faults are illustrated in

Fig. 1.2. Discoloration will occur in some timbers, such as blueing of softwoods, and this is due to fungi. The characteristic figure of birds-eye-maple is due to fungus attacking the living tree and not during seasoning. Badly seasoned timbers may also twist, warp, cup, bow or spring. Other structural defects in timber are found in waney edged boards in which some of the bark has been left on. Thunder shakes—especially in African mahogany—are caused by some type of shock, so that what appears to be a hair crack across the timber is, in fact, a complete severing of the fibres, so that the wood can easily be broken with the hands and any such pieces should be discarded. Knots are the result of branch formation and, provided they are not very large and not very close together, then they are not a source of danger. Branches which have been damaged in the living tree usually produce knots which are loose and eventually fall out. These are called dead knots.

Conversion of Timber

Timber is sawn at the saw mills in various directions and into various sizes (Fig. 1.3). Flat sawn, plain sawn or "through and through" sawn boards are the most economical, but as previously stated, the tendency of shrinkage, producing warped boards, is very great. Quarter sawing produces much more stable boards, but there is some restriction in size.

Sawn timber sizes are to be standardized in millimetre thicknesses of 16, 19, 22, 25, 32, 36, 38, 40, 44, 50, 63 and 75 and in widths from 75 mm to 300 mm in steps of 25 mm.

The small user of wood will deal in sizes of softwood, such as 25 mm × 50 mm (1 × 2 in.), 50 mm × 75 mm (2 × 3 in.), 75 mm × 100 mm (3 × 4 in.), 38 mm sq. ($1\frac{1}{2}$ in. sq.), 50 mm sq. (2 in. sq.), 25 mm × 150 mm (1 × 6 in.). The important thing to note is that these are sawn sizes and if the wood is to be planed then these sizes are still quoted, but any planing must reduce the size at least 4 mm ($\frac{1}{8}$ in.). For instance, 25 mm × 50 mm (1 × 2 in.) will have a finished size of 21 mm × 46 mm ($\frac{7}{8}$ × $1\frac{7}{8}$ in.) and 25 mm × 150 mm (1 × 6 in.) will probably finish 21 mm × 144 mm ($\frac{7}{8}$ × $5\frac{3}{4}$ in.). Hardwoods are often ordered to various finished thick-

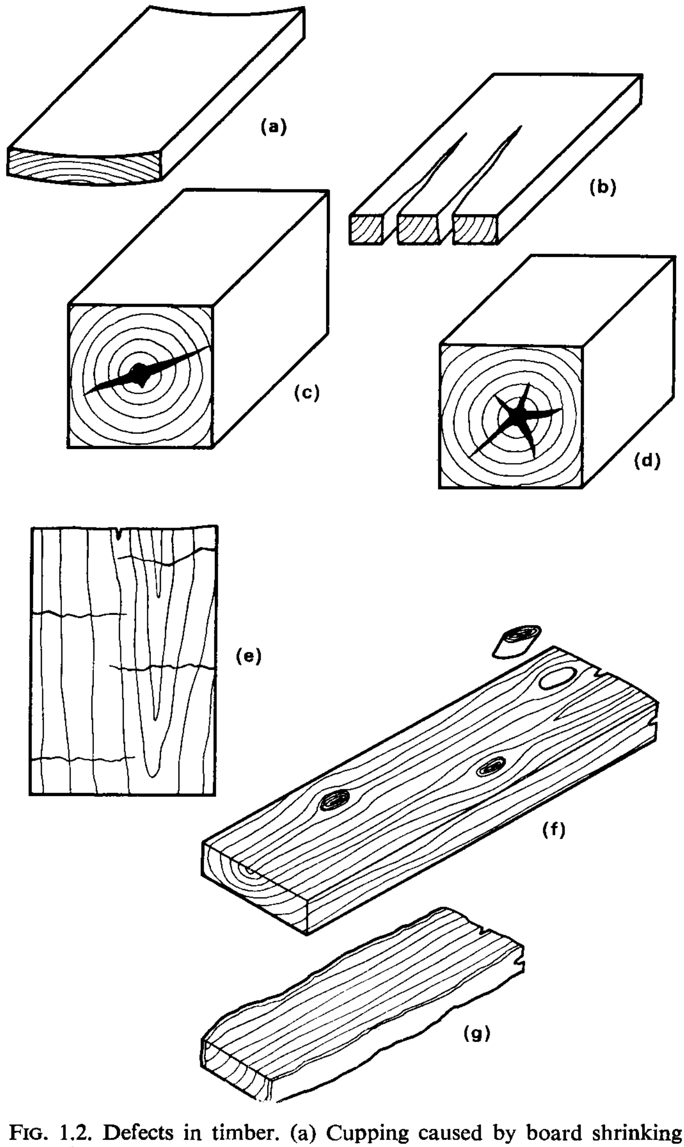


FIG. 1.2. Defects in timber. (a) Cupping caused by board shrinking away from the heart. (b) End splits. (c) Heart shake. (d) Star shake. (e) Thunder shake. (f) Knots and dead knots. (g) Waney edged.

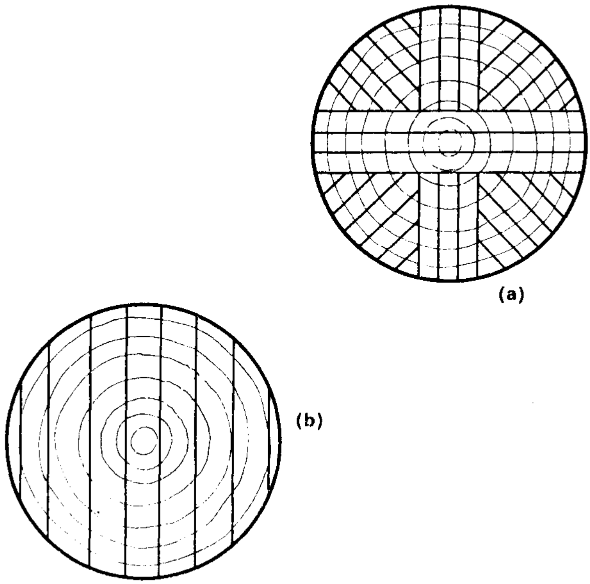


FIG. 1.3. (a) Quarter sawn for least warping. (b) Flat sawn for economy.

nesses, but it must be realized that they will be prepared from the same thickness stuff. For instance, both 21 mm ($\frac{7}{8}$ in.) and 19 mm ($\frac{3}{4}$ in.) finished size material will be prepared from 25 mm (1 in.) boards, but because of the extra machining, the 19 mm ($\frac{3}{4}$ in.) boards may be dearer than 21 mm ($\frac{7}{8}$ in.) boards. Softwood boards are planed to standard width, but hardwood boards are mainly sold in random widths. When ordering planed timber, stipulate "planed all round" (P.A.R.) when both sides and both edges are to be planed and "planed both sides" (P.B.S.) when the sides and not the edges are to be planed. Special sizes and shapes which are illustrated in Fig. 1.4 are prepared for the building trade and some useful ones are tongued and grooved (T and G) boards, feather edge weather boards, shiplap and sash bar.

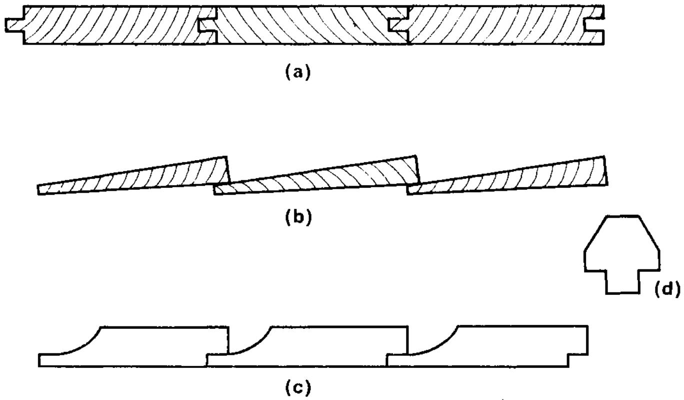


FIG. 1.4. Types of ready prepared timber. (a) Tongued and grooved. (b) Feather edge weather board. (c) Shiplap board. (d) Sash bar.

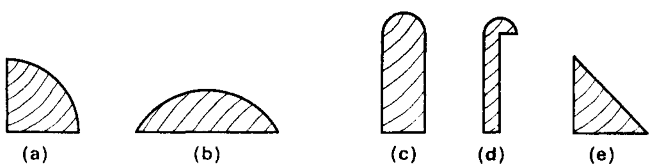


FIG. 1.5. Simple formed mouldings. (a) Quarter round. (b) Half round. (c) Parting bead. (d) Hockey stick. (e) Triangular.

Elaborate mouldings are at present out of fashion, except for picture framing, and most beadings are of simple form and are illustrated in Fig. 1.5.

Timber Pests

Unprotected timber is liable to attack from (a) fungus, (b) insects and (c) fire.

Fungus attack is mainly of two kinds, generally known as wet and dry rot. Wet rot is the condition of timber which is continually in contact with water, such as timbers and flooring around sinks, where dripping water occurs. This fungus is *Coniophora cerebella* or cellar fungus and it turns the wood dark brown or black with longitudinal splits. It can be easily eradicated by drying the wood thoroughly, cutting out and replacing damaged timber. Dry rot is caused by a fungus *Merulius lacrymans* which is very difficult to get rid of. It grows in humid and warm conditions so that proper air circulation is necessary to prevent its formation. Dry rot has the appearance of surface cracking, for all the moisture has been removed and the wood powders and collapses. There is always a characteristic musty smell which gives the first signs of its presence. Affected timber should be cut out and surrounding timber treated with one of the many preservatives available. Very bad outbreaks require treatment by specialist firms.

Insect attack on timber is the result of the action of larvae of several species of beetles, of which the common furniture beetle, death watch beetle and house longhorn beetle are the most common. The common furniture beetle (*Anobium punctatum*) is the one that causes most concern. It lays its eggs in cracks and crevices in furniture and this is one reason why so called parts that "will not be seen" should be smoothed, imperfections filled and excess of glue removed. The larvae stage may last from two to three years, during which time tunnelling in all directions is taking place. The beetle emerges from flight holes during a period from April to August, and it may only live a few days, during which time it mates and eggs are laid, more often than not in the timber from which it has emerged. Immediately any tell-tale signs of flight holes or small heaps of bore dust are noticed, steps should be taken to treat the wood with a suitable insecticide and periodic inspections should be made during the following years. Extensive attack in structural timbers should be treated with pressure equipment by specialist firms.

The use of timber creates a fire hazard, although many timbers have natural resistance to it, among them being teak, greenheart, jarrah and laurel. Timber and man-made boards may be purchased ready treated with chemicals which are flame and fire retardants. Boric acid and ammonium phosphate form the bases of many retardants, and proprietary liquids and paints can be purchased to treat existing fitments. However, where danger of fire from bunsens, blowlamps and other forms of heating is possible, the danger areas should be lined with asbestos sheeting.

Surface Features of Timber

If the cross-section of a log of wood is examined, the annual rings of growth are readily seen, together with two distinct colour divisions showing the sapwood and the heartwood and in some timbers there will also be seen the medullary rays (Fig. 1.6). When the log is cut into boards it will be seen how the annual rings produce the figure that gives timber its beauty; how the heartwood shows as a definite area edged with strips of sapwood

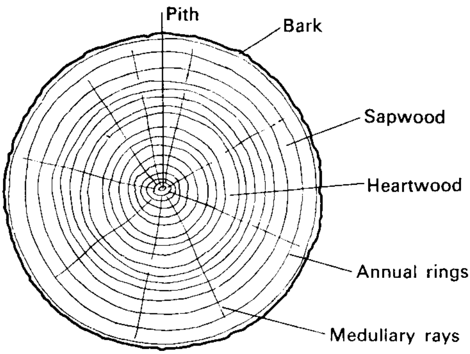


FIG. 1.6. Cross-section of a tree showing the main parts.

and how in certain woods such as oak and beech the medullary rays produce markings which are characteristic of the timber. Where branches enter the main stem, then knots are produced on the sawn board and the grain will be seen to have shaped itself around them. Other surface features are characteristic colouring and texture of the grain, whether it is open and coarse, as in oak, or close and fine as in most softwoods. However, for good working of timber, the most important feature to study is the direction of the grain. On the surface the grain formation around knots will pick up or tear in one direction, but run smoothly in the opposite direction. Interlocking grain in hardwoods will similarly run smooth or rough, and where this formation is in definite

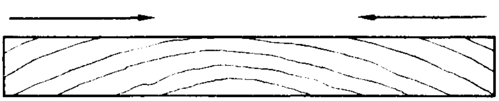


FIG. 1.7. The direction of the working edge grain is indicated by the arrows.

bands, as in sapele, then alternate bands run smooth and rough. On examining the edge grain, the direction of the grain will indicate the direction in which to work (Fig. 1.7). The fibres can be imagined to lie like the hair on an animal's back, so that in one direction it feels smooth while in the opposite direction it feels rough. It is in these areas of difficult grain that the woodworker must gain experience in how to handle tools and abrasives in order to obtain good surface finish.

Properties of Timbers

There are many hundreds of species of trees in the world, and although only a small number are in common use, there is a steady increase in this number. The softwoods are mainly used for structural purposes, while the hardwoods are used for furniture, highclass joinery and constructional work with special requirements. Table 1.1 gives a list of the commonest timbers with their properties. Generally the name of the timber and of the tree is the same, but often there are many local names and these are being standardized, a typical one being Redwood for Scots pine.

Veneers

Besides being cut into boards, some very finely figured hardwoods are cut into very thin slices or leaves called veneers. Thin veneers about 2 mm ($\frac{1}{16}$ in.) thick are cut with a knife, while thicker veneers up to 6 mm ($\frac{3}{16}$ in.) thick are cut with a saw. These veneers are usually cut from a log, slicing through and through as in the plain sawing of a log, so that the veneer has the normal grain of a board and all the leaves are very nearly identical with each other. These veneers are used decoratively for veneering furniture and surfacing man-made boards.

Another method of cutting veneers is to revolve the log against a knife so that a continuous peel of veneer rolls off, very much like unrolling a roll of gummed tape. This veneer is rotary cut and is used mainly in the manufacture of plywood. Because of this method of cutting, the figure of the wood is not the normal one.

Man-made Boards

Man-made boards are those made by using timber or wood fibre glued and re-formed to make large boards of various standard sizes and thicknesses (Fig. 1.8). The advantages of these boards are the lack of shrinkage, the reliability of the standard thicknesses, their availability in large widths, the fact that their warping characteristic is minimal. Their disadvantages are their restricted length and greater weight as compared with timber.

Plywood

Plywood was the first of the man-made boards and manufacturers still maintain a tremendous production of this commodity. The boards are made by cutting suitable lengths of rotary cut veneers and gluing them together so that the grain of each layer is at right angles to that of the previous layer. The number of veneers or plies will be odd and will vary to make up thicknesses of plywood from 3 mm up to 25 mm. Millimetre sizes are normal,

TABLE 1.1.
SOFTWOODS

Timber	Average weight		Colour	Uses	Properties
	kg/m³	lb/ft³			
Douglas fir *Pseudotsuga taxifolia*	528	33	Reddish-brown	General building construction, sleepers, flag poles, ladders.	Works well, needs care when nailing. Very pronounced figure.
Hemlock *Tsuga heterophylla*	404	29	Grey-white to yellow	General construction, flooring.	Works moderately well. Strong but not resistant to decay.
Larch *Larise decidua*	592	37	Dark red-brown	Fences, gates, flooring, buildings, pit timbers.	Works well. Takes nails and glue well. One of the hardest and toughest of the softwoods.
Parana pine *Araucaria brasiliana*	640	40	Straw to brown with characteristic red streak	Interior joinery, ladders.	Easy to work. Takes glue, stain and paint well. Tends to split on nailing.
Redwood *Pinus sylvestris*	512	32	Yellow-brown to reddish-brown	General work for carpentry and joinery.	Easy to work. Strong and moderately hard. Nails, glues and screws well.

Western red cedar *Thuja plicata*	352	22	Pink to dark brown	External buildings of all types.	Soft. Resistant to fungus and insect attack. Works well.
Spruce *Picea abies*	448	28	Almost white	Constructional work, musical instruments, masts, ladders, scaffolding.	Fairly strong. Resilient. Works easily. Takes glue, nails and screws well. Prone to decay.
Yellow pine *Pinus strobus*	416	26	Pale yellow	Pattern making, matches. Interior joinery, boat building.	A very stable wood. Works easily. Takes nails, screws and glue well.
Kauri pine *Agathis australis*	560	35	Whitish-brown or yellow	High-class joinery, shipbuilding, wood carving.	Works well and finishes to a fine surface.
Rimu *Dacrydium cupressimum*	640	40	Light brown	Joinery, turnery, plywood.	Moderately soft, strong, straight grain. Works and polishes well.
			HARDWOODS		
Afara (Limba) *Terminalia superba*	560	35	Light yellow, often with dark brown streaks.	Internal joinery.	Works well. End grain needs sharp tools. Care needed with nailing. Seasons well.

HARDWOODS—*continued.*

Timber	Average weight		Colour	Uses	Properties
	kg/m³	lb/ft³			
Agba *Gossweiler-odendron balsamiferum*	480	30	Salmon pink	General joinery, flooring.	Easy to work. Takes glue, nails and screws well. Strong. Resistant to decay.
Ash *Fraxinus excelsior*	704	44	Yellow	Sports goods, tool handles, motor bodies, aircraft construction.	Works well. Tough yet resilient. Not resistant to decay.
Balsa *Ochroma Spp.*	40 to 384	2½ to 24	White	Model making, heat and sound insulation, life belts.	Lightest and softest known timber. Little resistance to decay. Works easily.
Beech *Fagus sylvatica*	736	46	Pale brown	Chair making, wood-working, tools, turnery.	Works well. Takes nails well. Not resistant to decay.
Birch *Betula pubiscens*	672	42	Creamy white	Plywood manufacture, bobbins, clothes pegs.	Works well. Tough. Not resistant to decay.

Elm *Ulmus procera*	560	35	Pale brown	Coffin boards, wheelbarrows.	Difficult to work. Strong, tough. Difficult to split. Durable under water.
Gaboon *Aucoumea klaineana*	400	25	Pinkish-brown	Plywood, blockboard, laminboard manufacture.	Veneers well.
Greenheart *Ocotea rodioci*	1040	65	Olive-green to dark brown	Dock, harbour work, lock gates, fishing rods.	Difficult to work. Very strong. Flexible in small sections.
Hickory *Carya Spp.*	896	56	Pale brown	Tool handles, ladder rungs, sports goods.	Difficult to work. Very strong. Tends to split on nailing. Subject to decay.
Hornbeam *Carpinus betulas*	688	43	White with grey marks	Tool handles, pulleys, wood screws.	Fairly hard to work. Dense hard timber.
Iroko *Chlorophora excelsa*	656	41	Yellow to golden-brown	Joinery, flooring, laboratory benches.	Strong. Works fairly well. Takes nails, screws and polish well. Resistant to decay and insects.
Jarrah *Eucalyptus marginata*	896	56	Very dark red	Sleepers, bridge and railway work.	Not easy to work, very hard. Resistant to fungus, insect and fire.

HARDWOODS—*continued.*

Timber	Average weight		Colour	Uses	Properties
	kg/m³	lb/ft³			
Lignum Vitae *Guaiacum officinale*	1280	80	Yellow to olive-green to dark brown	Bushes, bearings, propeller shafts of ships, Goldbeaters' mallets, "Woods" for bowls.	Difficult to work. Very hard. Extremely resistant to fungus, insect and acids. Self-lubricating.
Lime *Filia vulgaris*	560	35	White	Excellent for carving (used by Grinling Gibbons), musical instruments.	Easy to work. Takes glue, screws, nails and polish well.
Maple *Acer saccharum*	752	47	Pale yellow	Flooring, especially dance halls and bowling alleys.	Works well. Hard. Resistant to abrasion. Bird's-eye maple caused by fungus.
Mahogany (African) *Khaya ivorinsis*	560	35	Reddish-brown	Joinery and cabinet making.	Works well, but interlocking grain tends to pick up when planed. Tends to warp.

Queensland walnut *Endiandra palmerstonii*	720	45	Light to dark brown. Often with coloured streaks	Cabinet work and veneers.	Hard, heavy and strong. Not very durable. Contains silica —is hard on tool edges.
Cape box wood *Buxas macowam*	880	55	Yellow	Construction of shuttles and engravings.	Close texture. Strong. Works and polishes well.
Natal mahogany (Stinkwood) *Trichilia emetica*	720	45	Reddish-brown	Cabinet and joinery work.	Strong odour. Works and polishes well.
Muninga *Pterocarpus angolensis*	800	50	Dark brown	Furniture, good class joinery.	Heavy, strong, durable. Works well. Sapwood liable to insect attack.
Mahogany (Honduras) *Swietenia macrophylla*	544	34	Reddish-brown	High-class cabinet making and joinery.	Excellent working properties. Very stable. Prone to insect attack.
Oak *Quercus pedunculata*	768	48	Cream to light brown	Cabinet making, constructional work, shipbuilding.	Very hard and durable. Sapwood attacked by insects. Works well.
Obeche *Triplochiton scleroxylon*	384	24	Creamy white	Interior joinery, substitute for softwoods.	Works easily. Not resistant to fungus and insect attack.

HARDWOODS—*continued.*

Timber	Average weight		Colour	Uses	Properties
	kg/m^3	lb/ft^3			
Sapele *Entandophragma cylindricum*	544	34	Reddish-brown bands of interlocking grain	Cabinet making, veneers.	Surface planing difficult, otherwise works well.
Sycamore *Acer pseudoplatanus*	624	39	White	Dairy utensils, cabinet making, turnery.	Works easily. Not resistant to decay, but withstands continuous washing.
Teak *Tectona grandis*	720	45	Dark brown	Cabinet making, garden furniture, general fittings in laboratories and chemical works.	Works well. Needs degreasing before glueing. Very strong. Resistant to temperature change, moisture, fire, acids, fungus and insects.
Walnut (African) *Lovoa klaineana*	56	35	Golden-brown	Cabinet making, joinery.	Works well, but grain sometimes picks up. Liable to warp.

Walnut (European) *Juglans regia*	672	42	Golden to dark brown	Cabinet making, veneers, turnery, rifle butts, air screws.	Hard, tough, but works well. Resistant to fungus, but attacked by furniture beetle.
Black bean *Castanospermum australi*	736	46	Dark brown	Cabinet work and general use.	Straight grain. Close texture. Works and polishes well.
Silky oak *Curdwellia sublimise*	592	37	Pinkish-brown	Cabinet work.	Wavy figure, sometimes difficult to finish. Polishes well.
Tasmanian oak *Eucalyptus gigantea*	768	48	Medium brown	Heavy constructional work.	Straight grained, strong. Works well.

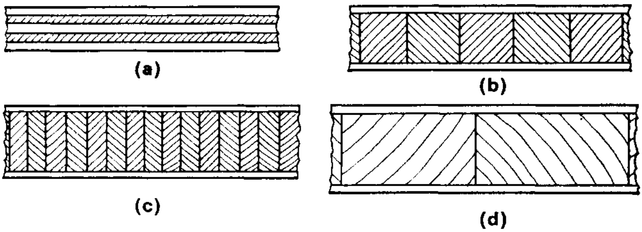


FIG. 1.8. Prepared boards. (a) Plywood. (b) Blockboard. (c) Laminboard. (d) Battenboard.

but they can be easily converted approximately to inches by counting 1 in. = 24 mm, although correctly 1 in. = 25·4 mm. Common sizes are 3 mm (⅛ in.), 4 mm (3/16 in.), 6 mm (¼ in.), 12 mm (½ in.), 18 mm (¾ in.), 24 mm (1 in.), but the inch equivalent is only approximate.

Plywood is obtainable made from a variety of timbers, of which birch, beech, gaboon and Douglas fir are the most common. Some plywoods are obtainable with one side veneered with a decorative veneer and with a cheaper veneer on the reverse side as a balancer.

Blockboard

This is constructed of 25 mm (1 in.) wide strips of softwood sandwiched between two layers of thick veneer, the grain direction of the strips being at right angles to the grain of the veneers. Blockboard is obtainable in thicknesses from 12 mm (½ in.) up to 50 mm (2 in.). The standard boards are 2400 mm × 1200 mm (96 in. × 48 in.), but can be obtained as large as 1650 mm × 5000 mm. Blockboard is a very stable board and although not as strong as plywood is considerably lighter in weight and much easier to work.

Laminboard

This is similar to blockboard, but has 9 mm (⅜ in.) wide core strips and hence is very stable. It is used in good class veneered work.

Battenboard

This is a cheaper constructional board which has 50 mm (2 in.) wide core strips.

Particle Boards or Chipboards

These are composite boards made from wood chips glued together with synthetic resin glue. The chips, often waste from joinery works, are graded to make a core of coarse chips sandwiched between layers of finer chips which together with glue are passed between presses and rollers to produce boards of standard 16 mm (⅝ in.), 18 mm (¾ in.) and 25 mm (1 in.) thicknesses. The boards are cut to a standard size of 2400 mm × 1200 mm (96 in. ×48 in.) but larger ones are manufactured.

Chipboard is a good cheap constructional board often ready surfaced for painting. It is unfortunately heavy compared with timber and is not as strong, in fact when used for shelving ¾ in. chipboard should be supported at least every three feet.

Veneered chipboard is obtainable in 18 mm (¾ in.) thickness and in widths ranging from 225 mm (9 in.) to 750 mm (30 in.) in steps of 75 mm (3 in.) and in lengths up to 3·00 m (10 ft). The boards are veneered on both sides and both edges, making them much stronger than plain chipboard and very much more economical in use. Chipboard is not suitable for normal jointing, but it will take glue, nails and screws well.

Hardboard

This is made from soaked wood fibres rolled under high pressure and temperature to produce homogeneous boards of standard thicknesses. Boards 2400 mm × 1200 mm (96 in. × 48 in.) and 3 mm (⅛ in.) thick are normal size, but thicknesses up to 12 mm (½ in.) are manufactured and various other larger and smaller sized panels are marketed. Hardboard is also obtainable in standard, medium and oil tempered grades, the latter being suitable for exterior work. The boards are obtainable in a variety of surface finishes, such as reeded, fluted, leather grain and perforated, the latter being very useful for storage and display purposes when used with special fittings. It can also be obtained ready surfaced with stove enamel and melamine.

Hardboard can be worked with normal hand tools and is used mainly for panels and as a cheap substitute for plywood. It is normally fixed with panel pins or hardboard nails, but where panels are used on movable parts, such as doors, then the panels should be glued as well as pinned. It is recommended that on any framework hardboard should be supported at intervals of 375 mm (15 in.). Before fixing, the hardboard should be conditioned by thoroughly soaking for 24 hours before using, and then set aside to dry.

Chapter 2

Saws and Sawing

It is absolutely essential that a technician, whatever his trade, must be familiar with the tools of his craft; how to use them and how to care for them. So often we hear the expression "a bad workman blames his tools", but it is equally true that good tools are necessary for good work. Make sure the best tools possible are available by ordering the best within the amount of money allowed by the authority. This is also true for the amateur. Cheap tools are false economy and if the craftsman needs the best, then it is even more important that the amateur uses tools of the best quality. Good tools need proper maintenance and proper housing, but for most technicians this will present no problem for they will probably use large, well-equipped workshops already well organized. There are, however, many who will have small preparation rooms in which everything must be done and there will be a temptation to heap everything into a box or cupboard. Technicians spend so much time organizing laboratory equipment that they often fail to organize themselves. This jumble is not only bad for the tools, but is dangerous and very frustrating when searching for something small, so tools should be housed in racks, chests or cupboards in an orderly method so as to be easily accessible. Suggestions for simple racks and cupboards are given in the last chapter, but most technicians will devise a method suitable to their own particular conditions.

All cutting tools and most other tools are wholly or partly made of steel and the great enemy of steel is rust. When tools are in regular use in a warm, dry atmosphere there is little danger of them rusting, but if they are used only occasionally some form of protection is necessary. A felt pad soaked in oil is useful just to wipe chisel blades, saws and other tools before putting them away. Polythene bags may be used to house small tools such as drills. Where tools are kept in boxes or cupboards, use rust inhibiting papers.

Before embarking on a description of individual tools, a word to the student who is unable to attend a definite course. However carefully one demonstrates to a group of students, there are always the few who are unable to carry out a process without individual attention to correct their errors. This must also be true of those who learn from books. The learner reader is therefore advised to try to carry out the methods as described, but also to ask a senior technician to correct any faults which may arise.

Saws

The initial preparation of timber is done by saws, from the great chain saws used for felling trees, the large circular and band saws in the saw mills to the smaller saws of the workshop. In the workshops, saws are used for cutting timber to approximate size, for rapid removal of waste and for cutting joints. They are divided into three kinds—hand saws, back saws and frame saws—and although each has a particular role, circumstances may necessitate their change. For instance, a tenon joint may have to be cut with a hand saw and thin wood prepared with a tenon saw.

Hand Saws

Hand saws are divided into rip saws and cross-cut saws (Fig. 2.1). The rip saw has large teeth and the number per inch, usually stated as the number of points per inch or 25 mm, is between 3 and 5. The rip saw is used for cutting timber along the grain. The cross-cut has finer teeth, between 6 and 10 points per inch or 25 mm, and is used, as the name suggests, for cutting across the grain of the wood. Examine these saws and notice the shape of the teeth. Run the teeth carefully between the thumb and index finger and notice that the teeth protrude. Look carefully and see how each alternate tooth has been set to one side or the other. This is called the "set" of the saw and its purpose is to make the saw kerf, or cut, wider than the blade of the saw and so allows the blade to move smoothly across the wood. If a saw sticks or squeaks, it is probably because the kerf is not wide enough and the saw needs setting and sharpening. Although sharpening is not impossible for the amateur or inexperienced worker, it is best to have it done by an expert "saw doctor", for it is a very skilful operation needing much care.

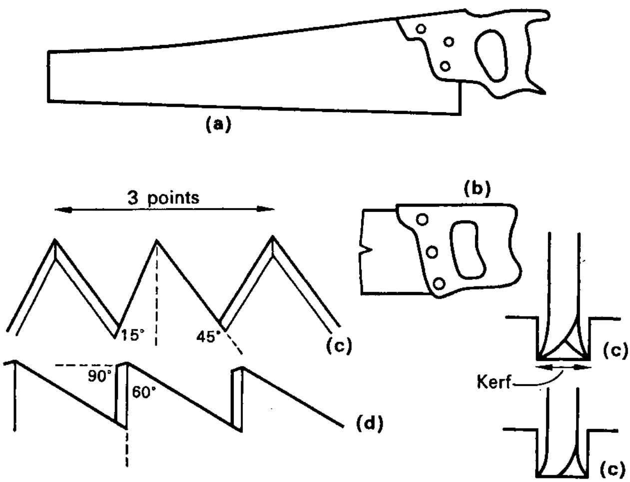


FIG. 2.1. (a) Typical shape of hand saw which may be a rip saw or cross-cut saw. (b) A modern type of moulded plastic saw handle. (c) Detail of rip saw teeth and cutting action in making the kerf. (d) Detail of cross-cut saw teeth.

Returning to the hand saw, hold it out at arms length and notice it remains flat, whereas a piece of mild steel of similar thickness would bend. The blade has been specially hammered to give it tension. Again, if the blade is bent it will recover its flatness. Look at the end of the blade and notice how the blade thins towards the back, thus enabling the blade to move through the wood more easily.

Figure 2.2 shows the correct way to hold a saw and it should be noted especially how the index finger points forward, giving support and help in direction. Throughout the chapters dealing with tools, notice how in holding most tools the thumb, the index finger and the last three fingers each do a separate job. The handle of the saw, despite its unusual shape, does fit the hand well, but it has one weakness, for the grain on one part of the

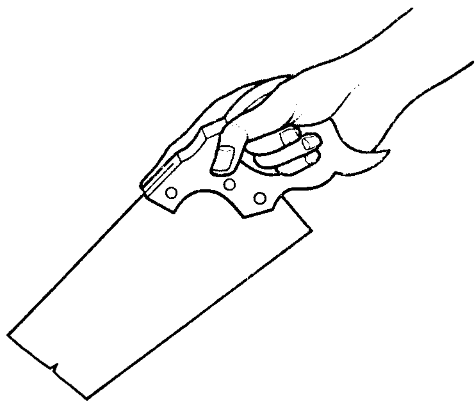


FIG. 2.2. The correct way to hold a hand saw.

handle is what is known as "short grain". Should the saw drop on to its handle, it invariably breaks across this short grain. It can be repaired by gluing the parts together and when the glue has dried, a hole is bored at an angle so that it will penetrate both parts and then a length of dowel rod is glued in. It is not always possible to repair the handle, but new ones can be obtained and these are easily fitted by removing the three screwed rivets. Recent development in plastics has given rise to moulded plastic handles together with some modification of the shape.

One of the secrets of good sawing is to hold the work firmly, for a piece of wood held on the edge of a table tends to move and make sawing very difficult. Large pieces of timber are cut on a sawing horse or trestle, or on a strong box, the height being such that the right knee and the left hand hold the wood firmly. If the wood is not too long it can be held in a vice, but throughout this operation the part being cut should be kept as near to the vice as possible to prevent too much vibration of the wood. If a sloping line is to be cut, hold the work in the vice so that the line becomes vertical. Always try to saw vertically and avoid making a cut with the saw at an angle. For cross-cutting large boards the work can be held on a sawing horse, or in the well of the bench whereas smaller work should be held in a sawing board or bench hook. The important point is that the work is given firm support at the back. The sawing board or bench hook is an essential piece of equipment which can be purchased or easily made by following the instructions given in the last chapter.

To start a saw cut, hold the saw firmly and nearly horizontal, stand well behind the saw so that the blade is easily sighted for being vertical, support the blade with the left thumb and draw the blade backwards until it has started a cut. Now remove the left hand and use it to hold the wood, always keeping it behind the blade away from the cutting edge. Saw through the wood with a steady stroke using the full length of the blade and gradually raising the blade until it is at about 60° to the work. There is no need for excessive pressure; just let the saw do the work and, as the operator, merely guide and push.

When using a cross-cut saw, hold the blade at about 45° and proceed as described above. Normally it is easier to saw straighter across the grain than with the grain, so that the cut can be made nearer to the finished line. If a large piece is to be cut off there is a danger that the weight of the wood will break the piece off together with a piece split from the remaining part. To avoid this, ask for assistance in holding the piece, or rest the elbow on the wood, loop the arm over the blade so as to be able to hold the unsupported piece, but support is only given towards the end of the cut.

Tenon Saw

Most joint work and the cutting of small pieces is usually done with a tenon saw holding the work in a vice or on a bench hook

(Fig. 2.3). The tenon saw has a brass or steel back which keeps the blade rigid, but note that this back does restrict the depth of cut that the saw can make. These saws may be 250 mm (10 in.), 300 mm (12 in.) or 350 mm (14 in.) in length with about 14 teeth per inch, but the 200 mm (8 in.) with an open handle is called a dovetail saw and, as the name suggests, is mainly used for cutting

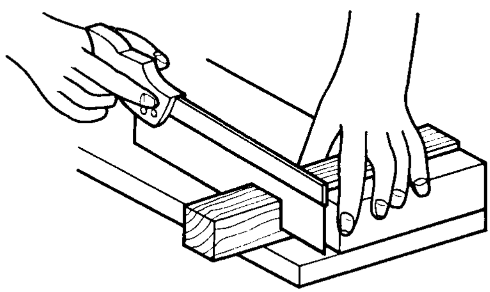


FIG. 2.3. Using a tenon saw with a bench hook.

that joint (Fig. 2.4). When using the saw it is held horizontally and as it is a fairly heavy saw, very little pressure is needed during cutting. The tenon saw is also useful for cutting thin boards such as plywood, hardboard and plastic laminates, and in every case the sheet is laid flat on the bench and the saw held very nearly horizontally. As there is always a tendency to tear the back surface, make sure that the best face of plywood, the smooth face of hardboard or the top surface of plastic laminates are

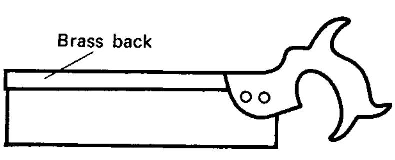


FIG. 2.4. A dovetail saw is similar to a tenon saw, but is smaller and has finer teeth.

always on top. If much plastic laminate is to be cut, it is best to keep a special tenon saw for this work and have it specially sharpened for use on plastics.

Bead Saw

Another saw in this group (shown in Fig. 2.5) is the small bead saw which, because of its size, has a small round handle and is useful when fine work or thin material is being used. This saw also makes an excellent dovetail or finger joint saw.

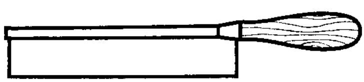


FIG. 2.5. A bead saw, which is used for very fine work.

Bow Saw

The remaining saws are mainly used for cutting curves or irregular shapes and of these the bow saw (shown in Fig. 2.6) is one of the earliest known saws. It is a frame saw in which the side members are joined by a loosely tenoned middle rail, while a blade is held between two handles and the whole frame is kept rigid by loops of string tightened in tourniquet fashion by a twist stick. The blades are replaceable and have holes punched in each end so that when the blade fits between the slotted pegs of each handle a small panel pin can be inserted to hold the blade in position. The blade is inserted so that the teeth point away from the holding handle which is the larger of the two. When in use the saw is held by this handle with both hands, while the other handle is used only when it is required to twist the blade. The bow saw will cut any curve, but the depth of cut is limited by the size of the frame. When the frame fouls the bench or the work while cutting, the blade is twisted by using both handles and the frame frees itself. A modern type of bow saw is the metal framed coping saw. The blade of this saw has small pins each end which fit into slotted lugs in the frame and these are used to turn the

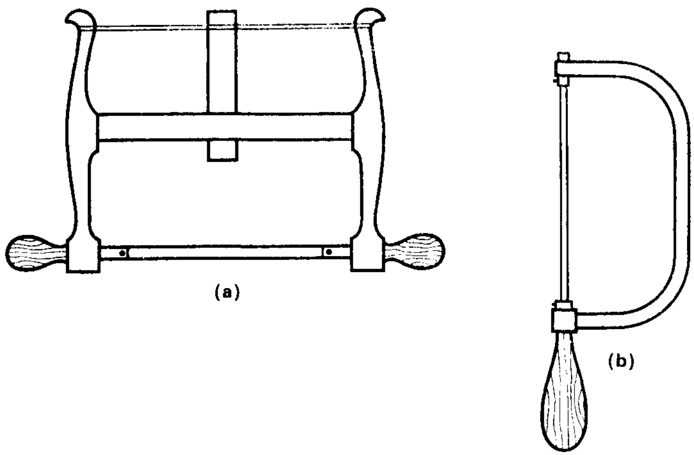


FIG. 2.6. (a) The bow saw which is used for cutting curved shapes. (b) The metal framed coping saw cuts curves and is useful for removing the waste when cutting dovetails.

blade. The tension in the blade is obtained by means of the screwed handle which tightens or slackens the tension in the frame. The blade must be fitted so that the teeth point away from the handle, and various grades of blades may be obtained for cutting wood, metal, or plastics. The saw will cut plywood and a fair thickness of timber and while it is especially used for curved work, it is also useful for removing waste wood when cutting dovetails, as will be described in a later chapter.

Compass, Keyhole and Pad Saws

When a shaped hole is to be cut at a distance from the edge of a board, a compass, keyhole or pad saw is used (Fig. 2.7). These vary in the shape of the handles that they have, but all have tapered blades fixed to the handles by screws. The blades are flexible but do not readily recover their shape if bent. A hole is bored large enough to insert the blade and it is then used in the same way as an ordinary saw following the marked line. The keyhole saw does have the special purpose of cutting the keyhole shape for an escutcheon.

If mitred corners are necessary, as on a picture frame, then a special mitre box or mitre sawing board is used, and if these are used carefully, the mitres can be cut accurately with a saw and

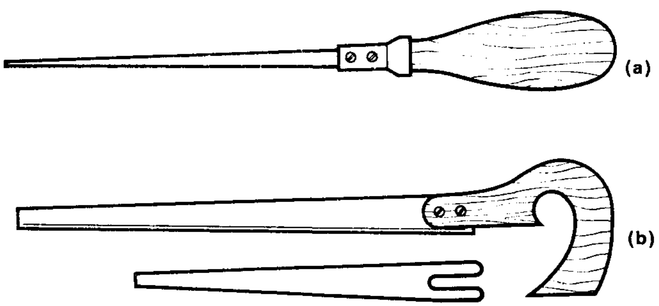


FIG. 2.7. (a) Keyhole or pad saw for cutting internal holes and shapes. (b) Compass saw with interchangeable blades for cutting large curves.

need not be trimmed. The box or board can be purchased ready-made, but can be easily made provided that great care is taken to mark out and cut the mitred cuts as described in the last chapter.

Occasionally saw cuts or grooves need widening. This can be done by covering or partly covering the original cut with a straight piece of wood and then making a further cut close to the piece of wood using a tenon saw.

Power Saws

The power-driven saw is rapidly becoming an essential part of the workshop equipment. There are two kinds—the power drill with saw attachments and the separately driven unit.

The power drill, which should be powerful enough to cut reasonable size timber, can have circular saw attachments, both rip and cross-cut, scroll and jig saw attachment. The circular saw is used for preparation of material, but can often be used for cutting some joints. The scroll and jig saw attachment will cut any shape and can be used for cutting some joints. The power drill with attachments is an economy of equipment and is probably quite adequate for the small laboratory, but it is limited in power and the interchange of attachments is inconvenient for the occasional cuts.

There is a range of portable tools which are complete in themselves and require no interchanging. These are available for the circular saw and jig saw.

Heavier fixed machines are available for circular saws, jig saws and band saws. These allow greater control over the work and enable the operator to carry out a larger range of work.

Any machine saw must be treated with respect and always used with great care and concentration to avoid accidents. Guards must be used on all moving parts and definitely the saw guard must be retained in position. Circular saws must be put on with the teeth pointing correctly in an anti-clockwise direction and the feed must not be too fast for the motor. The hands must be kept well away from cutters and if the work is close to the saw, a shaped stick should be used to push and guide the work. As with hand tools, all types of saw blades must be kept sharp and the sharpening should be done by a saw sharpener.

Chapter 3

Planes and Planing

PLANES can be divided into two classes. Bench planes which are used for reducing timber to its final size and for smoothing the surface, and special purpose planes used for shaping and for producing special features, such as grooves and rebates. For many hundreds of years planes have been made of wood except for the cutters, but gradually over recent years metal planes have been introduced and wooden ones are fast becoming obsolete. Nevertheless, many craftsmen prefer good wooden planes as they handle well, run smoothly, are light and easy to keep in good condition. The advantages of the metal planes are their ease of adjusting the cutting iron, and the absence of wear on the sole and mouth. There are some makes which combine the best qualities of both, that is a wooden body, metal sole plate, and adjustable blade.

Metal Planes

The general form of the metal planes is illustrated in Fig. 3.1 and they are obtainable in the following sizes (Table 3.1.).

TABLE 3.1.

	Length	Width of cutter
Smoothing plane	225–250 mm (9–10 in.)	44–72 mm (1¾–2⅜ in.)
Jack plane	350–375 mm (14–15 in.)	50–72 mm (2–2⅜ in.)
Fore or Trying plane	450 mm (18 in.)	72 mm (2⅜ in.)
Jointer plane	525–600 mm (21–24 in.)	72 mm (2⅜ in.)

Large metal planes may have corrugated soles which reduce friction and make them easier to use.

The jack plane is the general purpose plane of the group and is the one most frequently used. The smoothing plane is used for cleaning up, smoothing surfaces, and for working on small sizes of timber. The fore plane, trying plane and jointer plane are used for larger work, especially for truing long edges. Metal

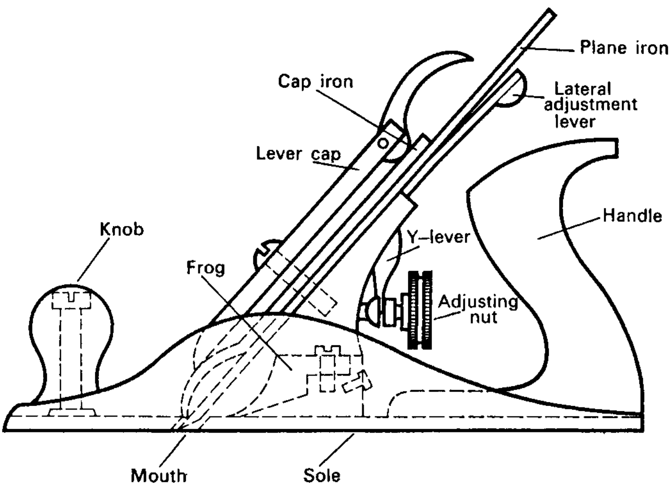


FIG. 3.1. Metal plane showing the various parts.

planes are made of castings and hence are easily broken when dropped, especially the narrow webb each side of the mouth. It is possible to weld or braze the break, but usually the sole then requires resurfacing on a surface grinder. Steel planes require careful storage for damage to the sole plate will cause corresponding blemishes on the surface of the wood. When laying the plane down on the bench at any time, lay it on its side so that neither the cutter nor the sole become damaged. Normally planes kept in a warm atmosphere do not rust, but to be on the safe side wipe the plane over with a smear of non-corrosive oil. A piece of felt soaked in oil is useful for this purpose. The wooden handles of both wooden and metal planes are liable to break across the short grain, for this is always a source of weakness, but new handles can be purchased for both types of planes. The metal plane handle is held by a small screw at the toe of the foot and by a long bolt fitting through the entire length of the handle, and by unscrewing both these, a new handle can easily be fitted. With the wooden plane the old handle must be chopped cleanly away from its socket and a new one fitted and glued in position.

Every woodworker should learn how to take a plane to pieces and reassemble it. To do this, lift the lever cam and remove the lever cap, but it is not necessary to remove the lever cap screw. Take out the cutting iron which is in two parts secured by a screw, which should be slackened so that the two parts can be separated into the cutting iron and the back or cap iron. These two parts are reassembled so that the cap iron is about 2 mm ($\frac{1}{16}$ in.) from the cutting edge of the cutting iron and the assembled piece is fitted into the body of the plane so that the end of the Y-lever fits in the slot visible at the top of the blade. Notice that turning the brass knurled wheel at the back of the frog moves the blade so as to alter the thickness of the cut, while the movement of the lateral adjustment lever squares the blade in respect of the mouth. Replace the lever cap and press down the spring cam. To set the blade, hold the plane so as to sight along the sole, turn the brass adjusting wheel and watch the blade emerge from the mouth until it is a thin black line. Square the blade in the mouth by moving the lateral adjustment lever to the right or left. This procedure is carried out every time the blade is sharpened or requires setting.

Wooden Planes

The wooden plane illustrated in Fig. 3.2 also requires taking apart when the blade needs sharpening. To do this the plane is held so that the thumb holds the blade inside the throat of the plane and the fingers curl behind the mouth on the sole. The striking button is given a sharp blow with a mallet which will loosen the wooden wedge and the irons can be removed and then separated by slackening the fixing screw. The two parts known as the plane iron and the cap iron (Fig. 3.3) are reassembled after sharpening so that the back iron is about 2 mm ($\frac{1}{16}$ in.) away from

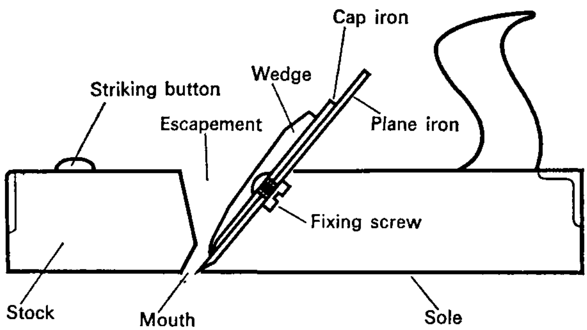


FIG. 3.2. Details of a wooden jack plane.

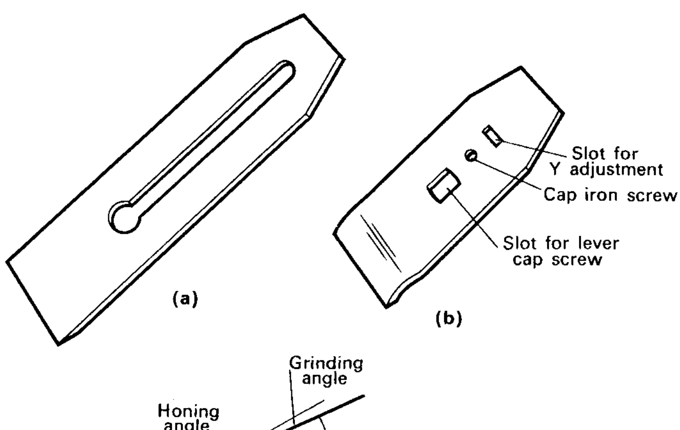


FIG. 3.3. (a) The plane iron. (b) The cap iron of a steel plane. (c) The sharpening or honing angle and grinding angle of a plane iron.

the cutting edge and the assembled piece, together with the wedge, are inserted into the mouth of the plane and the wedge is tightened by tapping with a hammer. The plane is held so as to sight along the sole, and then the iron is tapped with a hammer to advance the blade, and the striking button is tapped in order to retract the blade. Squaring the blade is done with side taps on the iron. If a plane iron were put into the plane without the back iron, the cut would produce a long ribbon-like shaving and a chattered surface on the wood. The purpose of the back iron is to support the cutting edge to produce a smooth finish and also to break the shavings so that they curl away from the blade. The back iron is never sharpened.

Inspection of the cutting iron will reveal that the sharpened edge has two angles—a grinding angle of 25° and a honing or sharpening angle of 30°. However, because of the thinness of the metal plane blade some manufacturers recommend that the two angles be combined as one sharpening angle of 25°. A plane blade rarely needs grinding, but when it is necessary it must be done on a sandstone wetted with water. A high speed carborundum wheel will generate too much heat and is likely to draw the temper from the fine edge.

Sharpening

Sharpening a plane iron on an oilstone is a frequent operation and is one that should be mastered, for it is a skilful operation to hold the blade at a constant correct angle. There are available, however, a number of honing guides which are usually in the form of adjustable screwed clamping plates with roller support.

Modern oilstones are mainly synthetic, manufactured from silicon carbide or aluminium oxide, both of which are extremely hard abrasives. The stones are graded fine, medium and coarse, but generally coarse and medium stones should be adequate, although for very fine careful finishing a fine stone is necessary. Double sided stones incorporating medium and coarse grades are available and are suitable for the smaller "prep" room. Oil must always be used on the stone so that it keeps the sharpening edge cool and also removes the metal particles, which if left can glaze the stone. The older types of oil, sweet oil and neatsfoot oil, have been largely replaced by fine lubrica oils now manufactured by oil companies. White spirit or paraffin can be used, but they require frequent application. Linseed or other vegetable oils should not be used as they tend to clog the stone as they dry. The stone must be kept in a flat condition by periodic rubbing with water on a flat stone surface, or on a piece of hardwood surfaced with a mixture of oil and carborundum powder. The oilstone is best fitted in a closed box so that when the lid is removed the stone stands proud of the lower half.

To sharpen a plane blade it is held in the right hand with thumb on top, the index finger lying along the edge and the remaining three fingers supporting underneath. The fingers of the left hand are spread equally over the top to give even pressure. The grinding edge is laid flat on the stone and the blade is then raised slightly to an angle of 30°, as illustrated in Fig. 3.4, but it must be

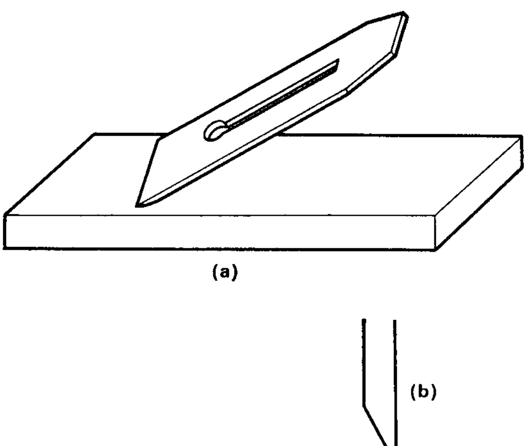


FIG. 3.4. (a) The plane iron being sharpened on an oilstone until a burr is produced. (b) An enlargement of the burr.

raised sufficiently so that any shadow between the edge and the stone disappears. Rub the blade backwards and forwards evenly over the full length of the stone keeping a constant angle. The edge will have been sufficiently sharpened when a burred edge can be felt at the back of the blade and unless this burr is felt the edge has not been sharpened. The burr is removed by laying the blade flat, and it is emphasized flat, on to the stone and moved once or twice over the stone until the burr is removed as a fine wire edge.

The jack plane blade is normally sharpened to have a slightly rounded profile, while other plane blades are made straight but with the corners slightly rounded to prevent the plane leaving a series of lined grooves.

Planing

The success of most woodworking operations depends largely on the work being held firmly and often, especially with assembled work, this can tax the ingenuity of the operator. Generally speaking, work for planing is held on the bench against the bench stop or in the vice.

It should be noted that all woodworking tools and equipment are made for right-handed users, and while no attempt should be made to make left-handers work oppositely, it does mean that they will need to adapt and improvize equipment for their own particular use.

When planing wood there are three surfaces to consider; the large face surface, the edge surface and the end surface. To plane the face surface, hold the plane as in Fig. 3.5, stand with the body leaning over the bench to get well behind the work and position the feet so that whether the piece is 150 mm (6 in.) long or 1·3 m (4 ft) long the movement is one continuous stroke. Work evenly over the surface of the wood and with each stroke gradually transfer the pressure from the left hand at the beginning of the stroke to the right hand at the end of the stroke. This keeps the plane moving in a straight line and avoids rounding at the ends.

The surface planed is tested for flatness in all directions using a try square, a steel rule or a steel straight edge. The work is held to the light so that a thin even line of light can be seen between the straight edge and the work surface. When it is flat it is marked with the conventional face mark (ℓ) and called the "face side". Both the face mark and the following edge mark (∧) are necessary because these are the two surfaces from which all testing and marking out is carried out.

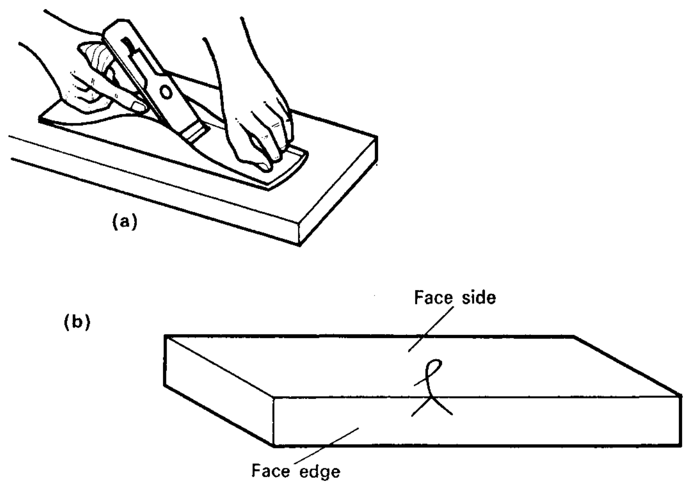


FIG. 3.5. (a) The correct way to hold a steel plane for surfacing. (b) The face side and face edge showing face and edge marks.

To plane the edge the work is held in the vice as in Fig. 3.6 with the face mark outwards. The plane is held with the thumb and the fingers curling underneath, so that they run along the surface of the wood as the stroke proceeds, helping to balance and keep the plane square with the work. Again pressure on the plane is adjusted to produce a straight stroke and the edge is tested for straightness and for squareness with the face side. The edge is marked with the conventional face edge mark. Narrow, short edges can often be planed more accurately on a shooting board.

Both in surface and edge planing consideration of the grain of the wood must be taken into account and this has already been described in Chapter 1. The most difficult surface to plane however, is end grain, because of the tendency to pull the fibres apart and so break away the wood at the end of the cut. To prevent this, some form of stop must be used, or planing must work away from the edge. Various methods of planing end grain are illustrated in Fig. 3.7. Small size work is held in a shooting board

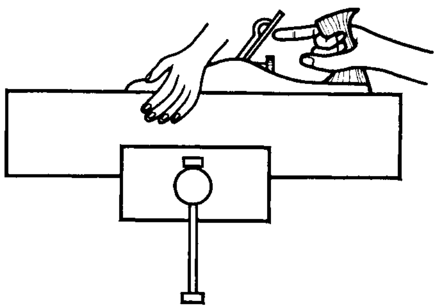


FIG. 3.6. The correct way to hold the work for edge planing.

which has a stop against which the end grain is held. This piece of apparatus if accurately made not only prevents the wood splitting, but it also ensures that the work is square. Details for making a shooting board are given in the last chapter. Larger work is held in the vice with a waste piece cramped to it. Other small pieces are held in the vice with a waste piece behind the direction of the cut. Long end grain is held in the vice and planing is worked from both ends towards the middle. Another method is to bevel the edge with a chisel, but care must be taken with the last cut. Figure 3.7 also shows how this is done when truing rails and legs in table constructions.

Sloping work should be planed towards the end grain and chamfers and bevels should be planed with the plane angled so that it strokes towards the end grain.

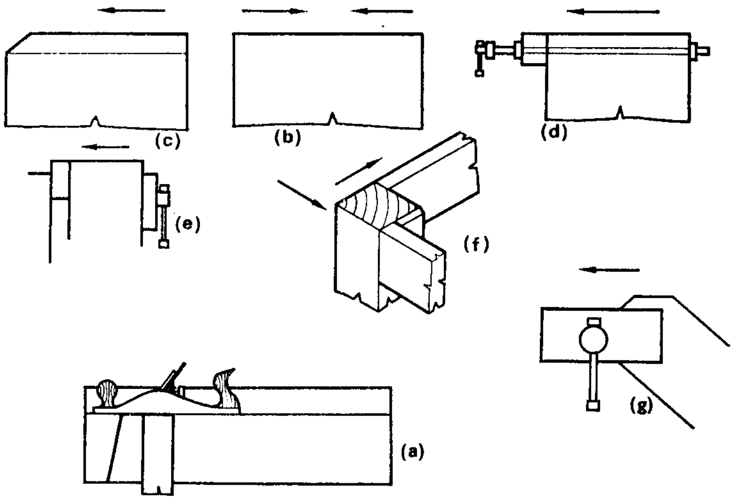


FIG. 3.7. Methods of planing end grain. (a) In a shooting board. (b) From both ends to the centre. (c) Towards a bevelled edge. (d) Using a waste piece held with a sash cramp. (e) Using a waste piece held in the vice. (f) Bevelling edges and planing away from the edge. (g) Holding work at an angle so that planing is horizontal and towards the end grain.

Preparation of timber to size should be carried out in the following order:

(1) Plane and mark face side.
(2) Plane and mark face edge.
(3) Gauge and plane to width.
(4) Gauge and plane to thickness.
(5) Saw and plane to length.

Special Purpose Planes

Rebate and Side Fillester

A rebate (or rabbet) is a recess made along the edge of a piece of wood and it is generally cut with a rebate plane (Fig. 3.8). This is a much narrower plane than the bench plane and has a blade which is the full width of the sole. The width of the cut is governed by the fingers curled under the plane acting as a distance guide. An improvement on this method is to fit an adjustable fence to the plane, in which case it is called a side fillester. The plane is also fitted with a depth gauge so that by adjusting both the fence and the depth gauge, any number of accurate rebates can be cut.

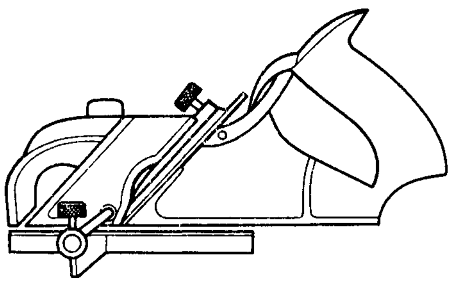


FIG. 3.8. The side fillester or rebate plane used for making rebates.

Some planes are fitted with a spur cutter which will cut the fibres in front of the cutter and so enable it to make a rebate across the grain without danger of splitting the wood. The plane usually has two alternative positions for fitting the blade, the front one enabling the plane to work up into a corner. The blade adjustment is made by a lever near to the handle and as the movement is vertical, care must be taken not to use the lever as a thumb rest. When using the plane, start the cut at the front of the rebate and gradually work backwards increasing the length of the stroke. The plane must be kept pressed into the side of the wood and also be kept square with the work.

The Plough or Grooving Plane

The plough or grooving plane shown in Fig. 3.9 makes grooves of standard size according to the interchangeable cutters supplied with it. These usually range from 3 mm ($\frac{1}{8}$ in.) to 12 mm ($\frac{1}{2}$ in.)

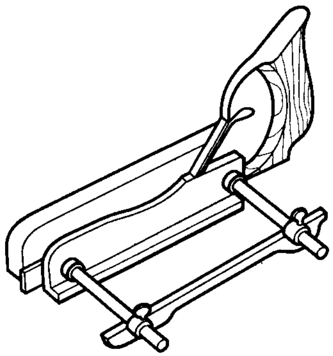


FIG. 3.9. The plough or grooving plane which is used to make grooves.

in steps of 2 mm ($\frac{1}{16}$ in.). The plane has two round bars as arms on which a fence slides to a required position and is then secured with thumb screws. An adjustable depth gauge allows the plane to make a groove of constant depth. When using the plane the cut is made at the front of the groove and the stroke is gradually lengthened until full length strokes are made. Where a required rebate is wider than the cutter of the rebate plane, a groove or series of grooves can be ploughed, and the rebate plane can then be employed to complete the final width.

Shoulder Plane

The shoulder plane illustrated in Fig. 3.10 is an all metal plane with an open mouth and a blade equal to the full width of the sole. It is obtainable in sizes 18 mm ($\frac{3}{4}$ in.) to 38 mm ($1\frac{1}{2}$ in.) wide. The planes already described have the blades set in the plane at an angle of 45° and with the bevel of the blade on the underside. The shoulder plane has the blade set at a low angle of 20° and with the bevel uppermost. The blade is held by a screwed clamp and has a blade adjusting screw. Because of the low angle of the blade the plane works end grain much easier and cleaner and is used for cleaning up tenon shoulders, truing rebates and cutting tongues on the ends of boards.

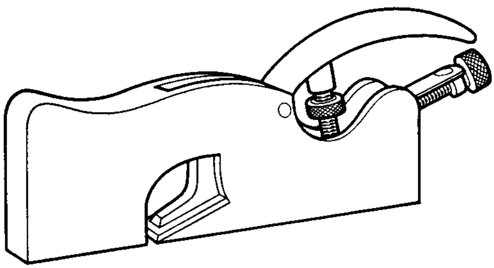


FIG. 3.10. The shoulder plane is used for truing shoulders of tenons and other joints.

Bullnose Plane

Figure 3.11 shows the bullnose plane which is a smaller edition of the shoulder plane and is similar in construction, but has the added convenience of a removable nose piece which then allows the plane to work right into a corner. Its convenient size allows the plane to be used inside a carcase or framework and in awkward places.

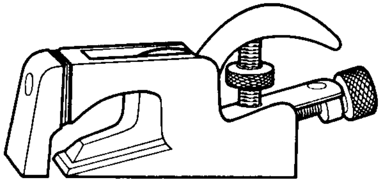


FIG. 3.11. A bullnose plane is useful for work in confined spaces.

Block Plane

The block plane (Fig. 3.12) is another small plane easy to hold in one hand and suitable for work in confined spaces. It has a low angle blade (as low as 12° in some cases) and hence is suitable for end grain work. The blade is adjustable but is not the full width of the body.

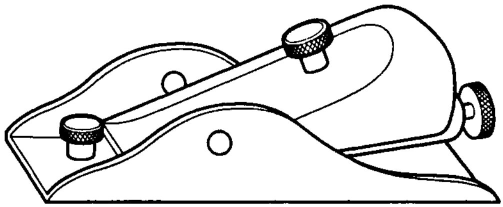


FIG. 3.12. The block plane is suitable for end grain work.

Router Plane

The router plane shown in Fig. 3.13 and, once known as the "Old Woman's Tooth" is used for cutting grooves, especially housings made to receive shelves. The router is held by its two handles and has various sized interchangeable cutters which are adjustable for depth of cut, enabling a groove of constant depth to be made.

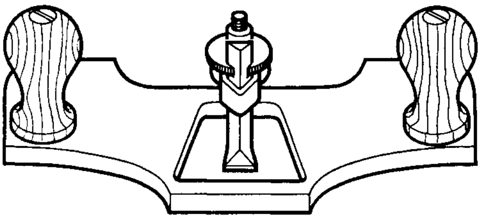


FIG. 3.13. The router used is for making grooves across the grain.

The Side Rebate Plane

The side rebate plane (Fig. 3.14) has left- and right-hand cutters which are adjustable for depth of cut and used for truing the sides of rebates.

The Spokeshave

The spokeshave is used to smooth curved surfaces after they have been rough sawn with a bow saw. There are two types; a flat for convex curves and a round for concave curves. The blade,

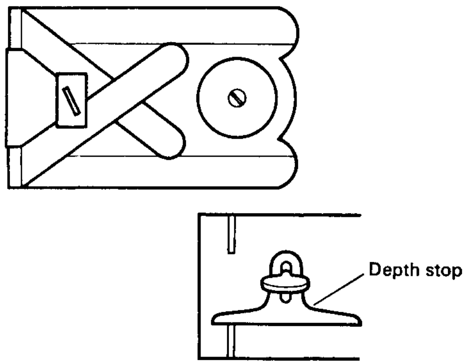


FIG. 3.14. The side rebate plane is used for truing up the edges of rebates and housing joints.

together with a cap iron, is held by a screw, and is adjustable for depth of cut and alignment by two knurled nuts. The blade is sharpened in a similar manner to a plane blade, but because of its size, it is well to make a wooden holder from a piece of 25 mm × 50 mm (1 in. × 2 in.) timber, bevelled and slotted at one end. The spokeshave is quite difficult to use at first because the operation is entirely a wrist action, so that the angle of cut is continually altering as the tool moves round the curve. If the spokeshave is held at an angle to the work so that a slicing cut is made, the ease and finish of the cut is often improved. The spokeshave must always be used towards the end grain and for circular shapes work proceeds from two opposite middle points towards the end grain.

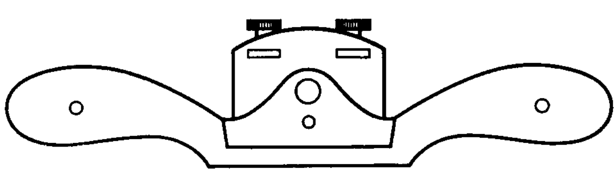


FIG. 3.15. The spokeshave is used for finishing curved surfaces, the flat for concave and the round for convex.

A flat spokeshave can often be used on flat surfaces where it is necessary to work close up into a corner, and it can be used for cutting chamfers.

Circular or Compass Plane

A plane used for large curved surfaces, both convex and concave and known as a circular or compass plane is shown in Fig. 3.16. It has a thin flexible sole with a large screw controlled lever which adjusts the sole to any required curvature. The blade is set somewhat steeper than the blade of a jack plane.

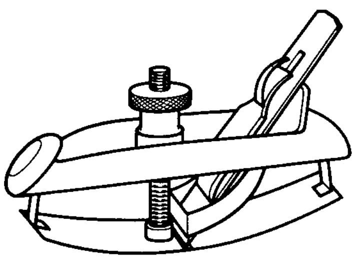


FIG. 3.16. The compass or circular plane with an adjustable sole to fit both convex and concave surfaces.

Toothing Plane

The toothing plane is used mainly for veneer work to roughen the ground (the wood on which the veneer is being laid) preparatory to gluing and laying veneer. It is similar in shape to the old-fashioned coffin-shaped smoothing plane, but has its blade set very nearly vertical as is shown in Fig. 3.17. On the back of the blade there is a series of parallel shallow grooves and as the blade is sharpened a saw-like edge is produced. The plane is moved over the wood in all directions to produce a rough surface suitable to hold glue.

Moulding Plane and Combination Plane

Moulding planes and combination planes (Fig. 3.18) are made of wood and have the sole of the plane shaped exactly to the same

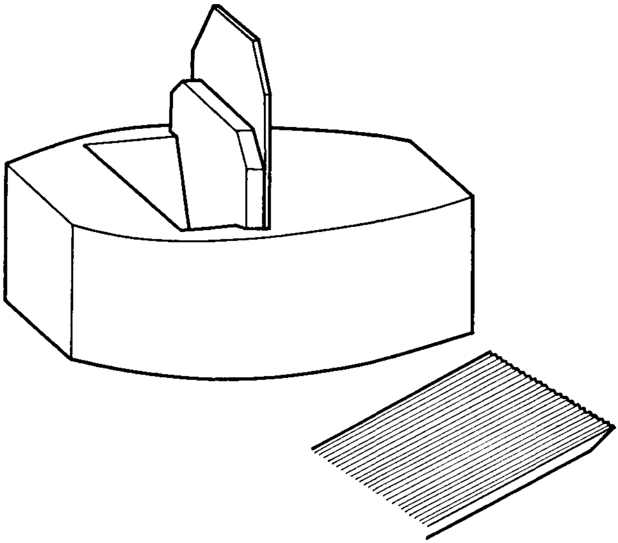


FIG. 3.17. The toothing plane with a serrated edged blade is used for roughing surfaces prior to veneering.

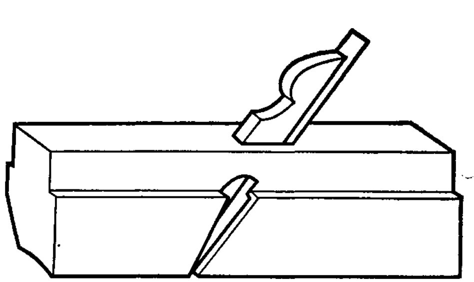


FIG. 3.18. Moulding planes may have various profiles and are used to shape the edges of timber to form mouldings.

profile as the cutter. Moulding planes are either round, hollows, or set moulding pattern, and are used at an angle to the work piece. The all metal combination plane looks like a more complicated plough plane, but has additional fences and depth gauges and has a variety of shaped cutters which can be combined to produce a number of mouldings.

Scrapers

The cabinet scraper is a piece of tool steel about 100 mm × 50 mm (4 in. × 2 in.) which has a burred edge. It is held in both hands with the thumbs behind the blade and pushed at an angle over the surface of the wood to produce very fine shavings. As the blade is flexible it can be bent so as to restrict the area over which it is used and hence is ideal for smoothing interlocking grain. Modern scraper planes have the blade fixed in a metal body very similar to

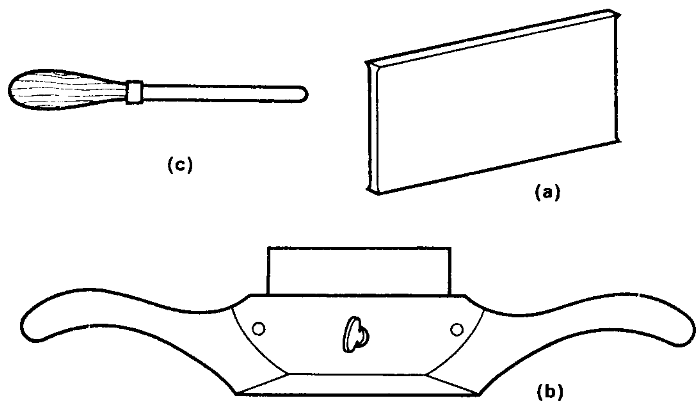


FIG. 3.19. (a) The cabinet scraper. (b) The handled scraper. (c) A rounded steel scraper sharpener. All used for smoothing awkward grain.

a robust spokeshave. The blades of both scrapers are first sharpened with a file and then on an oilstone to produce a straight edge. The blade is then held flat on the bench and a scraper sharpener or a round piece of hardened steel is stroked flat over the surface at each cutting face. The scraper is then held in the vice and each edge is stroked with the sharpener at an angle to produce four burred edges.

Another type of scraper uses small hooked blades which are expendable. These are obtainable in a variety of sizes and are very suitable for scraping large surfaces.

The Shaper Plane

A newcomer to the woodworker, the shaper plane (Fig. 3.20) is now a firmly established tool. It has a metal body with a moulded rubber handle, to which is attached a blade which itself is the sole

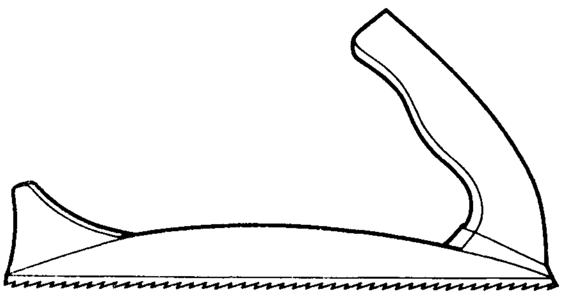


FIG. 3.20. The shaper plane which is a new type of forming plane with replaceable blade.

of the plane. The blade has a series of knife-like teeth along its entire length in the same fashion as a coarse file. The blades are expendable and are obtainable in various shapes and in grades suitable for cutting wood, plastics or metal.

Chapter 4

Chisels and Their Use

CHISELS are mainly used for the efficient and accurate removal of waste wood in joint-making and in many types of shaping. The common types are firmer, bevel, mortise and gouge, for the latter can be regarded as a round chisel. Chisel blades are made of carbon steel or alloy steels with softened tangs which fit into ash or boxwood handles which are smoothly round, hexagonal or otherwise conveniently shaped. Recently plastic handles of rigid polythene have been introduced and are found to be extremely practical. Chisels should be well housed to prevent damage to the cutting edges and it is recommended that they are kept in slotted racks, spring clips or in cloth rolls with separately sewn pockets.

Firmer Chisel

The firmer chisel (Fig. 4.1) is a robust tool which will stand up to fairly heavy blows with a mallet, but on no account should a hammer be used on it, as this will damage the handle and make it uncomfortable to hold. It will also make it potentially dangerous. Although plastic handles will stand up to hammer blows, it will be found that the mallet is a far more convenient tool to use. The chisel blade is made of steel of rectangular section with a slight taper from the tang to the bevel and a large range of sizes from 3 mm ($\frac{1}{8}$ in.) up to 75 mm (3 in.) wide are available.

The firmer chisel is used in jointing and shaping and is used horizontally or vertically with or without a mallet. The use of the chisel for vertical paring, as in removing a corner is illustrated in Fig. 4.2. The right hand firmly grasps the handle with the thumb

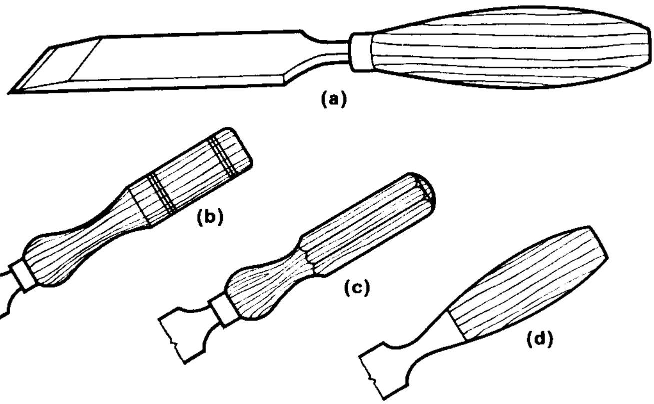


FIG. 4.1. (a) A firmer chisel with round boxwood handle. (b) A turned ash handle. (c) A hexagonal non-rolling handle. (d) A modern moulded plastic socket handle.

on top directing a downward force. The left hand is placed so that it holds the work firmly and allows the thumb and first finger to act as a guide for controlling the movement of the chisel. The chisel must be held vertically and only thin slices are cut at a time. For quick removal of waste, larger cuts can be made using a mallet, but only if the cuts are across the grain, for once the chisel is in the direction of the grain and a mallet is used, the wood is certain to split.

Cutting a halving joint (Fig. 4.3) is a typical example of horizontal paring. The work is marked out, held in the vice, and after saw cuts have been made, the chisel is held firmly in the left hand with the arm resting on the bench, and then the chisel is tapped with a mallet to remove the waste. The cuts should be made upwards towards the middle of the joint working from both sides. The chisel is then held with both hands and used perfectly flat to finally level the bottom of the joint.

A through housing is similarly cut using a chisel approximately the width of the groove, but if the housing is stopped and the

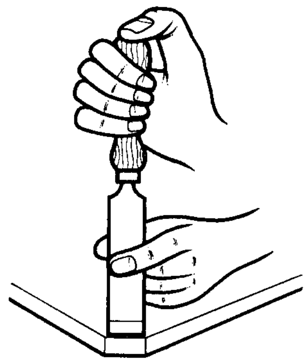


FIG. 4.2. Shows a chisel being used for vertical paring.

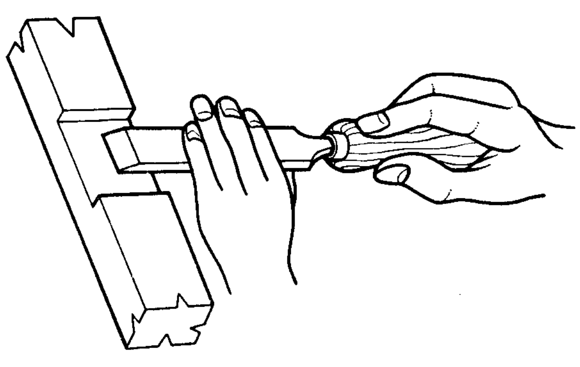


FIG. 4.3. Shows a chisel being used for horizontal paring.

groove is longer than the chisel blade, then use the chisel the reverse way holding it at an angle so that the bevel is parallel to the surface (Fig. 4.4). It should be noted that in all cases saw cuts are made first so that they control the area of cutting and prevent splitting beyond the marking out.

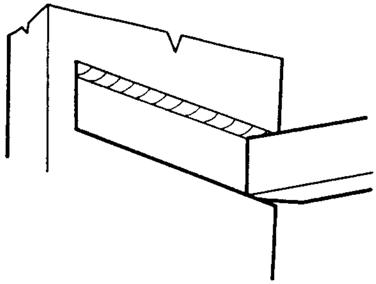


FIG. 4.4. Shows how the chisel may be reversed and used to cut on the reverse bevel.

When cutting a large rectangular hole or mortise, first bore out as much waste as possible and then remove the remainder with a firmer chisel and mallet, using the chisel across the grain in short cuts as in Fig. 4.5. The edges working with the grain are carefully trimmed without using a mallet.

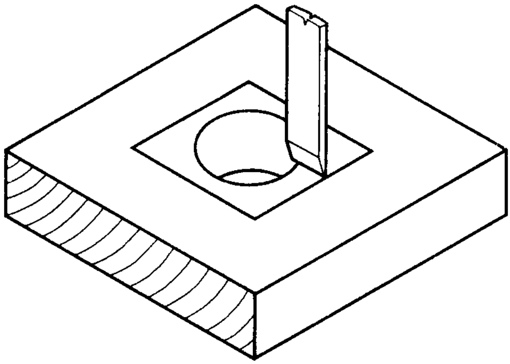


FIG. 4.5. Method of chopping out a large mortise by cutting across the grain after preliminary boring.

To cut a tongue on the end of a piece of wood, mark out and make a saw cut across the shoulder line to the depth required. Then hold the work in the vice and with a wide firmer chisel held in the gauged line, tap gently with a mallet and the waste wood will fall away as shown in Fig. 4.6. Precaution must, however, be taken to examine the side grain for straightness, otherwise the chisel will follow the grain of the wood and the joint may not finish square. If the grain is not straight then it may have to be cut with a saw.

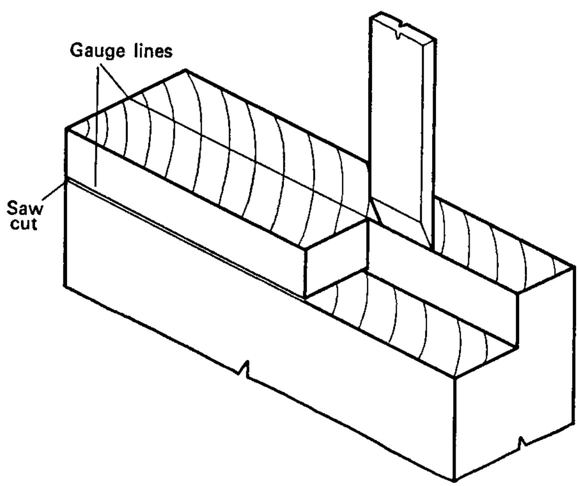


FIG. 4.6. A tongue on the end of a piece of wood can be chopped out with a chisel after first cutting with a saw across the shoulder.

Figure 4.7 shows how a rebate can be cut with a chisel, and often part of a stopped rebate must be cut with a chisel. After marking out hold the work in a vice, use a firmer chisel held across the grain so that it cuts up to the edge of the rebate and then use a mallet and make cuts to the depth of the rebate at intervals of about 6 mm (¼ in.). Then carefully chop out the waste working with the grain from both edges.

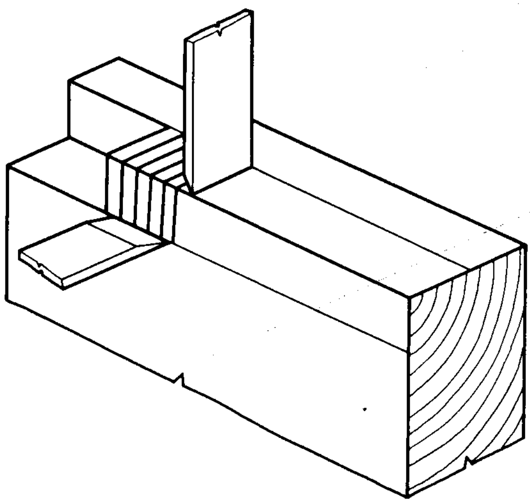


FIG. 4.7. Stages in chopping a rebate with a chisel.

Quick removal of waste, either from the full length of a piece of wood or from between two limits, is done by making a series of saw cuts to the required depth at about 12 mm ($\frac{1}{2}$ in.) intervals and then with chisel and mallet the waste is removed (Fig. 4.8).

Bevel Chisel

The bevel chisel shown in Fig. 4.9 has its edges bevelled and is used for fine paring and for cutting sockets where the angle is less than a right angle, particularly for cutting dovetails (Fig. 4.10). It is not such a robust chisel as a firmer chisel, and the mallet must, therefore, be used with care, but normally if the chisel is sharp there is very little need to use a mallet.

One example of the use of this chisel is for repairing an item such as a damaged lock stile. To do this, cut a piece of wood with sloping ends and larger than the damaged area. Mark out carefully the shape of this piece on to the damaged stile, and, after

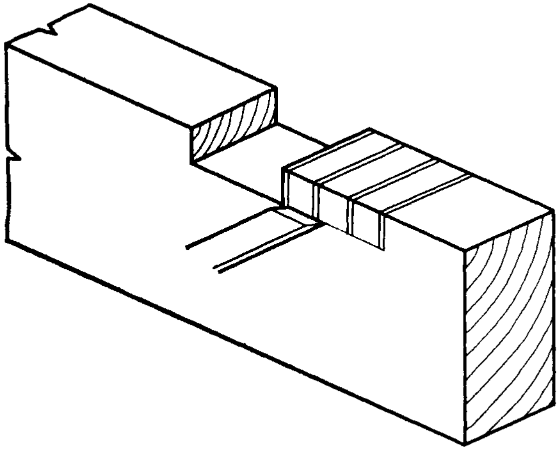


FIG. 4.8. Quick removal of waste wood done with a series of saw cuts and a final removal with a chisel.

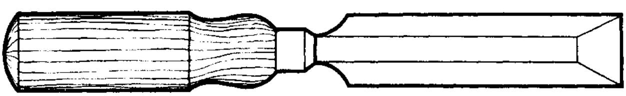


FIG. 4.9. The bevel chisel is used for fine paring and cutting of dovetails.

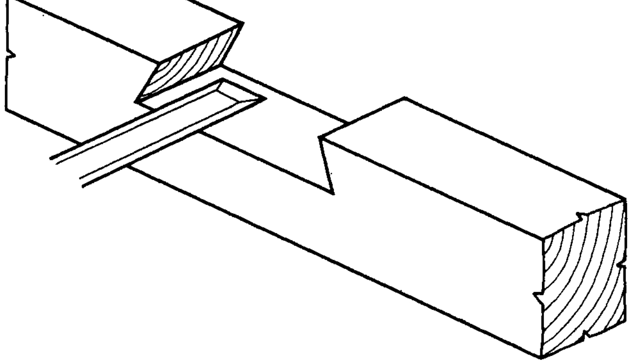


FIG. 4.10. Using a bevel chisel to clean out a dovetailed socket for repair work.

making suitable saw cuts, remove most of the waste with a paring chisel, finally levelling and cleaning the corners with a bevel chisel.

Similarly, when cutting the sockets for butt hinges, remove the waste with a bevel chisel holding the blade of the chisel with the forefinger and thumb of the left hand, the forefinger underneath blade acting as a stop to prevent the chisel overcutting (Fig. 4.11).

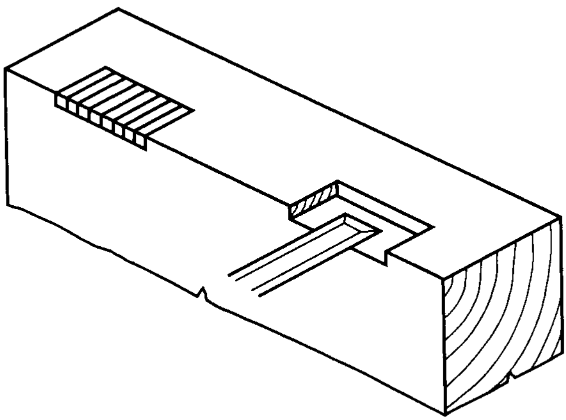
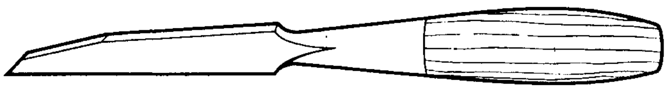


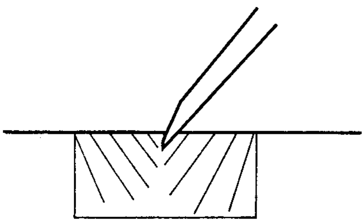
FIG. 4.11. Cleaning out a hinge socket with a bevel chisel after chopping down with a firmer chisel.

Mortise Chisel

The mortise chisel (Fig. 4.12(a)) is a very robust tool and has a handle which fits into a socket which is all in one piece with the blade, so that heavy blows can be made with a mallet without fear of damaging the chisel. As will later be explained, the mortise chisel is used for cutting mortises, and is the exact width of the mortise to be cut. To cut the mortise, hold the work in a vice, or clamped to the bench, and stand well behind the work in order to keep the chisel vertical. First make cuts to form a Vee, which piece is easily removed (Fig. 4.12(b)). Continue making cuts each side of the Vee, making the cuts deeper and more vertical as they



(a)



(b)

FIG. 4.12. (a) A typical socket handled mortise chisel. (b) Shows the successive cuts in cutting a mortise.

approach the ends of the mortise. After each cut the waste can be levered out, but at the ends of the mortise the levering action should be towards the middle otherwise the ends become bruised. If the mortise is a through mortise the cuts are started from both sides to meet in the middle.

Swan Neck Mortise Chisel

A specialist's tool which is used to cut large mortises in framed doors in which to fit mortise locks is known as the swan neck mortise chisel (Fig. 4.13). It is used after most of the waste has been bored out.

FIG. 4.13. A swan neck mortise chisel used for lock mortises.

Drawer Lock Chisel

The drawer lock chisel, another specialist's tool enabling sockets to be made on the inside of drawers for locks, is shown in Fig. 4.14. Its bent blade enables it to be used in a confined space.

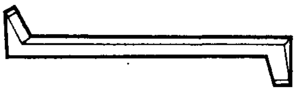


FIG. 4.14. A drawer lock mortise chisel.

Gouges

Gouges (Fig. 4.15) can be classed as round chisels and are normally of two types; firmer gouges, with the bevel on the outside, used for making hollows, and scribing gouges, with the bevel on the inside, used in making or scribing curved profiles.

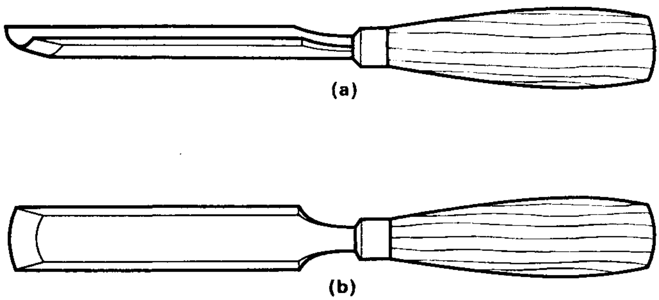


FIG. 4.15. (a) A firmer gouge with bevel on the outside. (b) A scribing gouge with bevel on the inside.

Gouges are available in a large range of sizes and curves and there is a further range containing a variety of shapes which are specially made for carvers.

Sharpening

Chisels must be sharp to cut efficiently and, like plane irons, have a grinding and sharpening edge. Grinding, which should be rarely necessary, is done on a wet sandstone and sharpening is done on an oilstone. Exactly the same procedure is carried out as for the plane blade, maintaining a constant angle and producing a burred edge, which is removed by laying the chisel flat on the stone and rubbing once or twice. It is customary to sharpen the chisel on the outer edges of the stone to avoid undue hollowing in the centre.

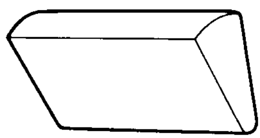


FIG. 4.16. An oilstone slip used for sharpening gouges.

Gouges require a special oilstone slip which is of triangular section with rounded edges (Fig. 4.16). The firmer gouge is sharpened on a slip stone and the burr removed by a rocking action on a flat stone. The scribing gouge is sharpened with a rocking action on a flat stone and the burr is removed on a slip stone.

Chapter 5

Marking Out and Testing

MARKING out is one of the most important features of woodwork and much of the success of a completed job depends on accurate and orderly marking.

For rough preparation timber can be marked out with a pencil, but once any accuracy of jointing is required then a cut line is essential. A cut line is not only thinner than a pencil line but it has the advantage that tools like chisels can actually fit into the line to make a last precise cut. Occasionally a very long straight line requires marking on the floor or on a board or on a piece of timber. The simplest way to do this is to stretch a piece of chalked string tightly between two points and to flick the string so that it produces a straight white chalk line.

Measuring

The steel tape and the four-fold boxwood rule (Fig. 5.1) are essential measuring tools. The steel tape is difficult to use for the accurate setting of gauges and the carpenter's four-fold boxwood or plastic rule is a much more convenient tool for this purpose and for measuring short lengths. Steel rules can be used, but unless they are stainless they tend to darken and obscure the divisions and figures. When a length has to be repeated many times, it is often best to mark this off on to a lath or thin straight edge, and it may not even be necessary to know its actual measurement. When measuring an internal distance between two surfaces, such as between the sides of a cupboard or between the walls of a recess, two overlapping laths can be held between the walls and

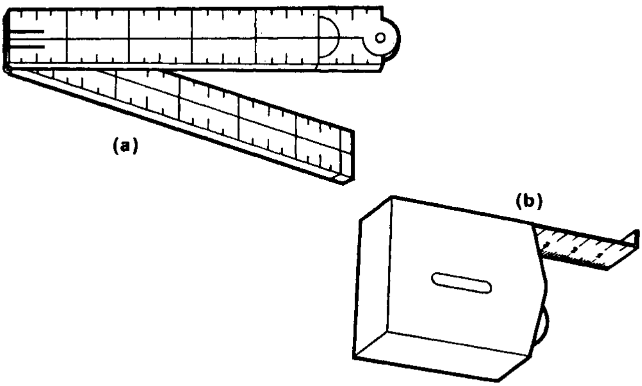


FIG. 5.1. (a) A four-fold rule. (b) A spring-loaded steel tape.

the position of the ends of the laths marked as illustrated in Fig. 5.2. This distance can be transferred directly to the wood being cut.

Gauges

Various marking gauges (Fig. 5.4) are used for marking parallel lines at a given distance from a face edge or side and the markings can be accurately repeated on any number of similar pieces. The simple marking gauge consists of a pointed marker set in a stem on which slides a stock which can be secured at any position by a boxwood or plastic thumb screw. The marking gauge is set to the measurement required with the thumb screw just tight, then by tapping one end or the other of the gauge it can be finely set to the exact size. When using a gauge hold the thumb behind the marking pin, the first finger curled over the stock and the remaining fingers around the stem. Hold the pin at an angle to the work and, keeping the stock well pressed against the side of the work, push the gauge firmly along. Digging the pin in deeply tends to make the gauge follow the grain of the wood instead of the line of the wood. To find the accurate centre of a width or thickness of wood, set the gauge approximately to the centre and then tap it until by testing from both sides the pin markings coincide.

A fairly accurate pencil gauge can be made by holding a pencil on the wood at a required distance, letting it rest on the second finger and at the same time letting the same finger act as a guide

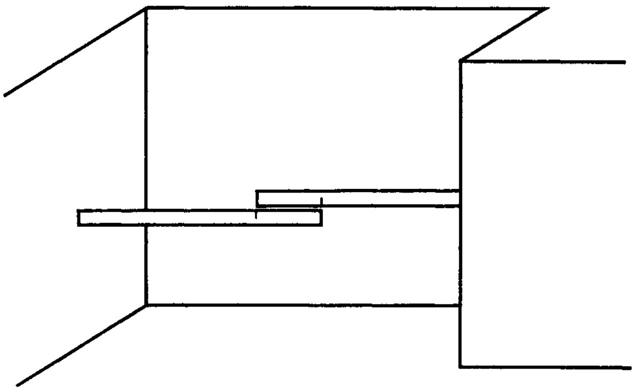


FIG. 5.2. Method of measuring an internal distance with two laths.

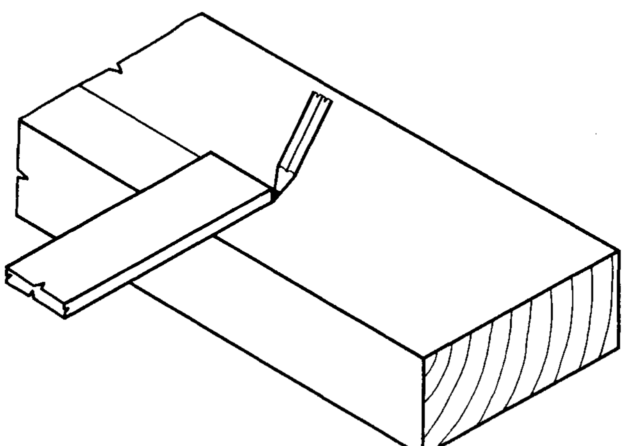


FIG. 5.3. Using a rule and pencil as a pencil gauge.

along the timber. Similarly, as shown in Fig. 5.3 a rule can be used by holding the rule at a required distance with the left hand, the fingers acting as a guide and holding a pencil against the end of the rule and allowing them to move along together.

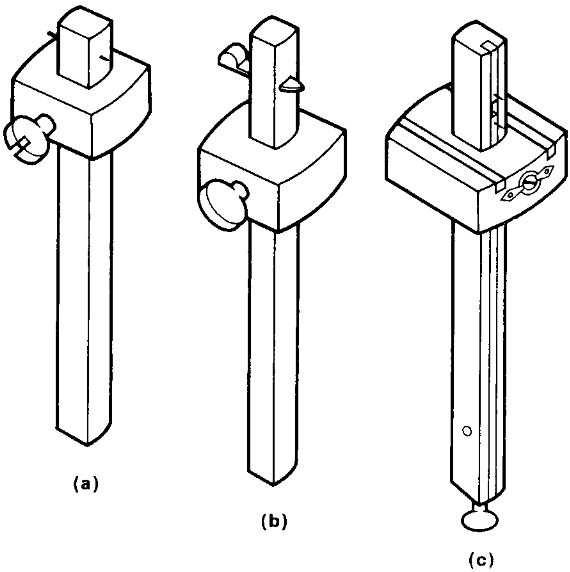


FIG. 5.4. (a) Marking gauge with single pin and adjustable stock. (b) Cutting gauge with a cutting blade held by a brass wedge. (c) Mortise gauge with two adjustable pins.

The Cutting Gauge

The cutting gauge is similar to the marking gauge only it has a sharpened cutter held by a small brass wedge and is used for marking across the grain because a marking gauge tears across the grain. The cutting gauge can also be used for cutting veneers, thin wood and small rebates.

Mortise Gauge

The mortise gauge has two pins, one fixed to the stem and one fixed to a brass slide which is operated by a thumb screw and is able to fix the distance between the two pins. The adjustable stock is held by a metal screw which needs tightening or slackening with a screwdriver.

The gauge, which is used in exactly the same manner as a marking gauge is always set to the mortise chisel which is to be used to cut the mortise joint. Both the mortise and the tenon are marked out with the same setting of the gauge as in Fig. 5.5, thus ensuring a correctly fitting joint.

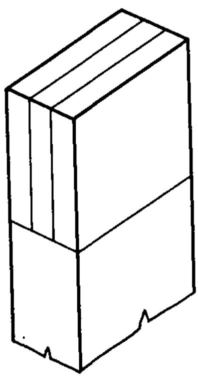


FIG. 5.5. A tenon marked out with a mortise gauge.

Try Square

The try square illustrated in Fig. 5.6 is a precision tool made either of all steel or of a steel blade in a wooden stock, and it is available in small and large sizes. It is used for marking lines square to a face side or face edge and is held by the thumb pressing the edge of the stock, the first finger holding the blade and the remaining fingers pressing on to the wood. The try square is used for testing the flatness of surfaces and also for testing the squareness of edges, frames, boxes, carcases and other work after gluing (Fig. 5.7).

The squareness of large frames, boxes and carcases is tested by means of a thin lath laid diagonally across both pairs of corners and the distance measured (Fig. 5.8). The work is adjusted until

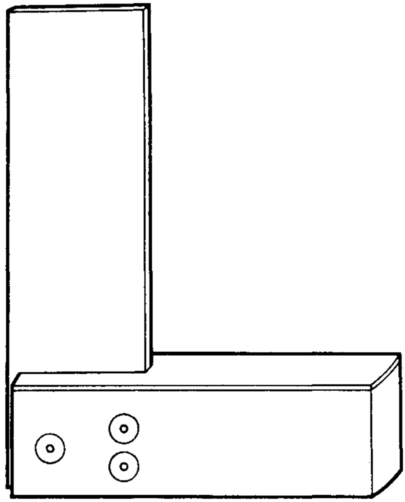


FIG. 5.6. A try square used for marking out and testing.

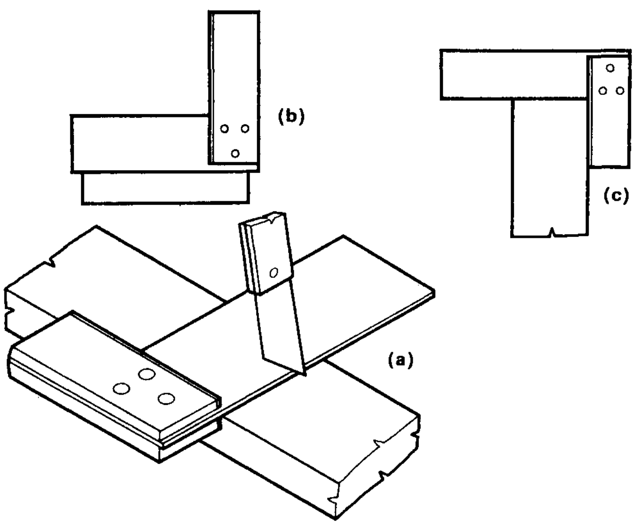


FIG. 5.7. (a) Using a try square and marking knife. (b) Testing for straightness. (c) Testing for squareness.

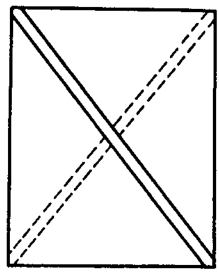


FIG. 5.8. For large rectangles test for equal diagonals with a pointed lath.

both diagonals measure the same, for only in a square or rectangle are the diagonals equal.

Bevel Gauge

There are two types of bevel gauges and these are shown in Fig. 5.9. They are the fixed 45° bevel or mitre square and the adjustable sliding bevel which can be set to any angle and is used in the same manner as a try square.

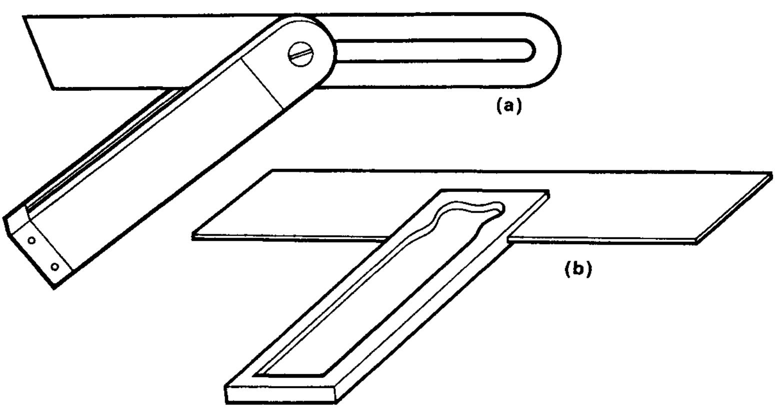


FIG. 5.9. (a) An adjustable bevel for use with any angle. (b) A fixed 45° bevel or mitre square.

Marking Knife

All cut lines are marked with a marking knife, the edge of which should be sharp and have one side only bevelled. When using a knife with a try square, always place the knife in the position required, slide the square up to it, and then make a firm cut line.

Wing Compasses

Wing compasses (Fig. 5.10) are made of steel, one leg being pointed and the other having a knife edge so that it cuts the fibres of the wood, the latter leg being secured in position by means of a thumb screw bearing on a steel quadrant. Very large circles can be drawn with a pencil and a length of string or with trammels. Ellipses and other geometrical figures can be set out by methods described in the chapter on drawing.

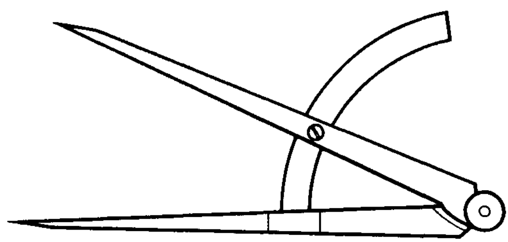


FIG. 5.10. Wing compasses have one leg pointed and the other a flat cutting edge.

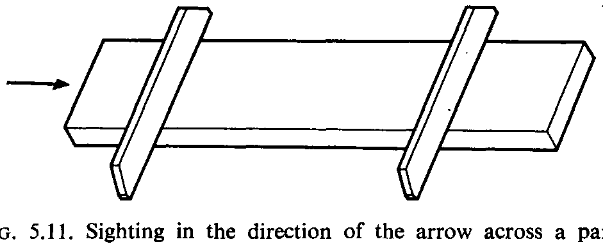


FIG. 5.11. Sighting in the direction of the arrow across a pair of winding strips to test for straightness.

Winding Strips

Winding strips consist of two lengths of well-seasoned hardwood each about 600 mm (2 ft) long and made perfectly straight and parallel (Fig. 5.11). By placing these two pieces one each end of a board or framework and sighting the edges of the two strips, the board or frame can be tested whether it is twisted or "in winding".

Spirit Level

The spirit level (Fig. 5.12) is a necessary instrument used for testing the level of all types of surfaces.

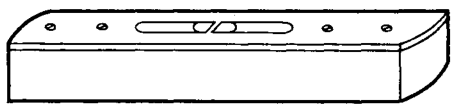


FIG. 5.12. The spirit level is used for testing horizontal levels.

Chapter 6

Hammers, Mallets, Screwdrivers and Allied Tools

Hammers

The hammer is an important woodworkers' tool and is used primarily for driving in nails and for use on metal punches and other metal equipment. Although a golden rule is to use metal against metal and wood against wood, it is sometimes more convenient to use a hammer on wood rather than a mallet. For example, a hammer is used in setting a wooden jack plane, for driving in wedges, or for fitting dovetails, as the taps are so light that no damage is done to the wood. Sometimes if heavy blows with a hammer are required, then a protective waste piece of wood should be used between the hammer and the workpiece. The flat peen of a hammer, provided it is smooth, is very useful for laying edge veneers.

The head of a hammer which is made of forged alloy steel has one round face which is smooth and slightly convex and should never be allowed to become damaged or chipped, and the other end flat, being called the flat peen, and is used for starting small pins and nails. The central eye which is softened is like a double ended dovetail, so that the handle fits in the eye and when steel wedges are driven in, the top spreads to form a rigid dovetail. The handle which is best made of hickory is well shaped to fit the hand and well balanced for easy handling. Loose heads and split handles are a source of danger and should be tightened or replaced. Hammers can have specified pre-shrunk handles which resist loosening. A modern innovation is the tubular steel handle with a shock absorbing rubber grip, but the wooden handle is still the more popular.

The main types of hammers are shown in Fig. 6.1. They are the Warrington, Exeter, Pin and Claw, the latter having a built-in nail remover. If the claw hammer is used for removing a nail from a surface which must not be damaged, a waste piece of wood should be interposed between the hammer and the surface. Hammers are specified by weight and are obtainable in a range from 0·11 kg (4 oz) to 0·66 kg (24 oz) but a 0·11 kg (4 oz) pin hammer and a 0·33 kg Warrington hammer are suitable for most kits.

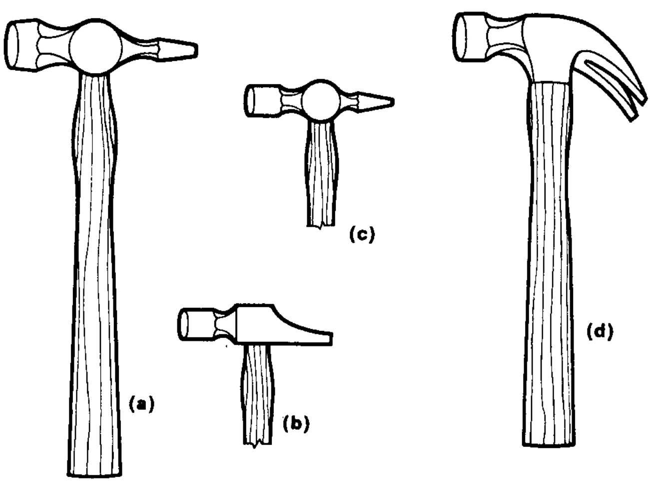


FIG. 6.1. (a) A Warrington hammer. (b) Exeter pattern hammer. (c) Pin hammer. (d) Claw hammer.

A hammer is held at the lower end of the handle (never choke it!) with the thumb on top and the fingers curled underneath. When using the hammer the action is a wrist movement and the hammer should be allowed to fall from a height of about 6 in. The tendency is to use an arm action and because the arm moves in a circular arc the nails are liable to bend. As the hammer face hits the nail head a slight forward movement of the hammer will help to counteract the tendency to bend the nail. A golden rule in sport is keep the eye on the ball and in nailing, too, keep the eye on the nail head. Hit with the centre of the hammer face and then the slightly convex shape will not indent the surface around the nail.

Mallets

A mallet (Fig. 6.2) is usually made of beech and has a tapered handle which tightens as it is driven into the mallet head. It is mainly used with chisels and in the assembly and taking apart of constructed joints. A rounded pattern usually made of boxwood or lignum vitae is used by carvers.

Pincers

Pincers (Fig. 6.3) are used for withdrawing nails and generally are more efficient than a claw hammer, especially when used on small nails and pins. A waste piece of wood should be used to prevent surface damage and the jaws should be kept in good condition to give good contact when closed.

Where technicians have to deal with opening numerous wooden packing cases, special nail pullers, case openers or wreckers are obtainable.

Screwdrivers

The various patterns of screwdrivers or turn screws are illustrated in Fig. 6.4. They are mainly distinguished by the shape of the handle and it is a matter of personal choice which one is selected. The wooden handles usually made of beech or box are fast being replaced by plastic. The blades which are made of carbon steel or alloy steel are either spade shaped or straight, but whichever type is used the end is always ground flat and square and never to a knife edge, or the corners ever rounded. The

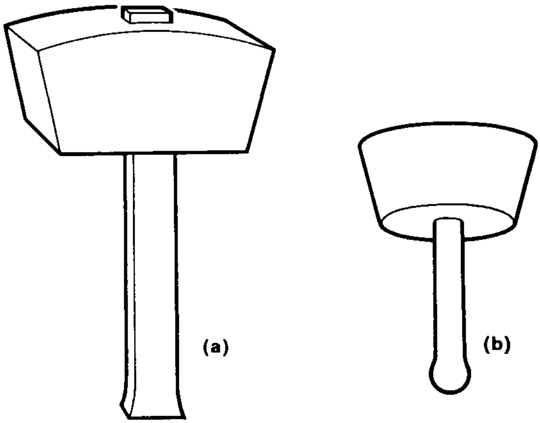


FIG. 6.2. (a) A wooden carpenter's mallet. (b) A carver's mallet.

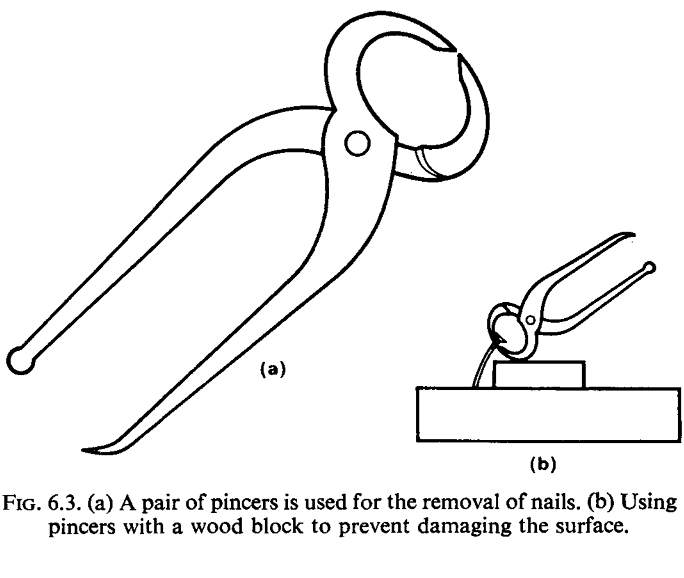


FIG. 6.3. (a) A pair of pincers is used for the removal of nails. (b) Using pincers with a wood block to prevent damaging the surface.

important point to note is that the tip of the screwdriver should fit the slot of the screw and in order to accommodate most gauges of screws a range of several sizes of screwdrivers is needed. A long screwdriver has no mechanical advantage over a short one, although it does tend to keep squarer with the screw, but a short stubby screwdriver has advantages when used in restricted areas. Other modern types of screwdrivers, which are often more con-

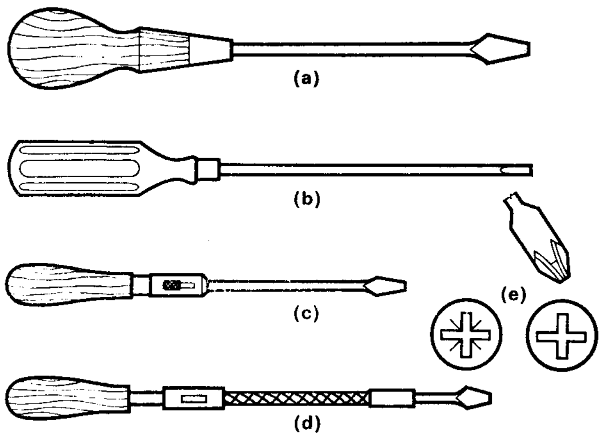


FIG. 6.4. (a) Screwdriver with spade blade. (b) Plastic handled screwdriver with flat blade. (c) Ratchet screwdriver. (d) Spiral ratchet screwdriver with interchangeable bits. (e) Cross-head screwdriver for Phillips and Posidrive screws.

venient to use than the fixed blade, are the ratchet screwdriver and the spiral screwdriver, the latter often being provided with interchangeable bits. Another essential screwdriver is the Phillips which must be used on the recessed cross-headed screws which are gaining in popularity on all types of equipment. The screwdriver bit for use in a carpenter's brace is most useful for large and difficult screws (Fig. 6.5).

The handle of a screwdriver comfortably fits the hand so that it revolves easily in the palm and the fingers of the right hand while the left hand supports the tip. The tip of a screwdriver is quite sharp, so the same safety rule applies as for chisels—keep both hands above the tip.

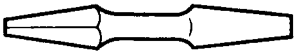


FIG. 6.5. Screwdriver bit for use with carpenter's brace.

A screwdriver is a precision tool and it should be cared for as such, for so often it is misused to prise open lids, force open cupboard doors, or used as a tommy bar.

Nail Punches

The nail punch (Fig. 6.6) is used for punching the heads of nails below the surface of the wood, or to help complete nailing in awkward places. When in use the base of the punch is supported by the little finger and only one blow at a time is delivered, because the punch tends to jump and so its position should be checked.

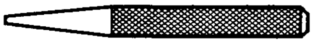


FIG. 6.6. A nail punch which may have a round or square point.

Chapter 7

Boring Tools and Their Use

THE making of holes in wood is mainly carried out with the carpenter's brace for large holes and the wheel brace for small holes.

Carpenter's Brace

The carpenter's brace (Fig. 7.1) which is specified by the diameter of the sweep, has a wooden or plastic head and handle which are fitted with plain or ball race bearings, the latter obviously being preferred. The plain brace works with a continuous sweep and is suitable for most straightforward work, but it is well worth purchasing a ratchet brace which can be used in confined spaces or with restricted movement. The chuck has a pair of jaws which are machined with plain Vee grooves or alligator grips and as the body of the chuck is screwed down, the two jaws close round the

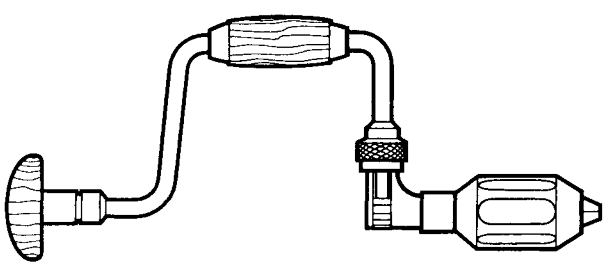


FIG. 7.1. A carpenter's ratchet brace. It is also obtainable as a plain brace without a ratchet.

square tapered shank of the inserted bit. Extension pieces are available consisting of a chuck with a long spindle which is inserted into the main chuck. This type of chuck is suitable for full sweep boring in awkward or remote places. When designing or fitting out interiors to cupboards, any necessary holes should be positioned so that the brace can be used easily.

Bits

There are a number of bits, all with square shanks which are used with the carpenter's brace (Fig. 7.2). The plain centre bit which is suitable for holes ranging from 4 mm ($\frac{3}{16}$ in.) to 38 mm ($1\frac{1}{2}$ in.) has a long centre point, an outer cutter called the "nicker" and a wide chisel-like cutter which removes the waste. The nicker cuts the fibres to prevent the tearing and splitting of the wood and it is double the distance of this cutter from the centre which determines the size of the bit. Holes are bored from the face side of timber and when the point of the bit appears on the far side, the work is reversed and the boring is completed from the far side. Although a similar procedure can be carried out on plywood, it is often best to place a waste piece of wood behind the work and then to bore continuously into the waste wood. Work can be bored vertically on the bench working on a waste piece of wood, or horizontally with the work held in a vice. Semi-circles can be cut by cramping a waste piece of wood to the work and boring a hole with its centre on the dividing line.

A more expensive improved pattern bit has a screw point which draws the bit into the wood and so relieves the worker of having to exert a great pressure.

Larger holes are bored with an expansive bit, which is similar to the improved bit, but has a dovetailed channel into which slide one of two different sized cutters and which is then secured by a screw. The cutters are marked with half-scale dimensions so that they can register with a datum line to give the correct sized hole. The smaller cutter usually cuts holes from 18 mm ($\frac{3}{4}$ in.) to 38 mm

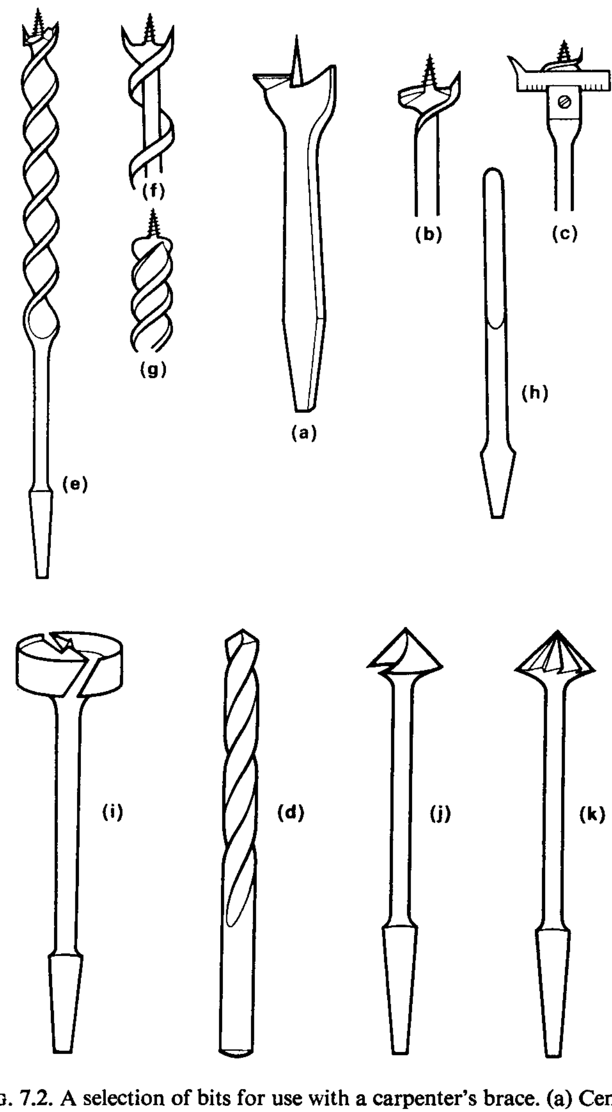


FIG. 7.2. A selection of bits for use with a carpenter's brace. (a) Centre bit. (b) Screwed point centre bit. (c) Expansive bit. (d) Twist drill. (e) Jennings twist bit. (f) Irwin pattern. (g) Gedges pattern. (h) Spoon bit. (i) Forstner bit. (j) Snail countersink. (k) Rose countersink.

($1\frac{1}{2}$ in.) diameter and the larger cutter cuts holes from 31 mm ($1\frac{1}{4}$ in.) to 75 mm (3 in.) diameter.

Smaller diameter holes, deeper holes and holes into end grain are best cut with twist bits. These are available in standard lengths to bore holes up to 38 mm ($1\frac{1}{2}$ in.) diameter and in special short lengths called dowel bits which bore holes from 6 mm ($\frac{1}{4}$ in.) to 16 mm ($\frac{5}{8}$ in.). There are many patterns of twist bits, of which the Gedges is useful for rough work, the Irwin is suitable for softwoods and also the Jennings, which is the most accurate to use and the one to be recommended.

The flutes which help to maintain a straight bore clear the waste wood, but when withdrawing the bit the screw point should be released and then pulled straight out to remove all the waste. When boring with this type of bit it is useful to set up a try square near to the bit so that with occasional sighting to the side of the work a hole square to the work can be bored. Because of the long screw point care must be taken in controlling the depth of the bore, in order that the point does not penetrate and mar the far side.

The auger bit, which is used for very large deep holes, has a welded eye at the top in which a wooden or metal handle is fitted.

The shell and spoon bits are used for small diameter holes and for boring into end grain, but they are now largely obsolete.

The Forstner bit has a very small locating point and a circular rim to guide the bit to cut a very clean hole. It is specially useful for making blind holes and partial holes.

Included with the bits used in a brace are some which do not bore holes, but are closely connected with boring.

The countersink bit is used for shaping the top of a screw hole so that the head of the screw lies flush or below the surface of the wood. Of the two types illustrated the snail horn is used only on wood, whereas the rose bit is more universal, being used on wood, plastic and metals.

The screwdriver bit is extremely useful for driving large screws, or for removing awkward screws and is obtainable in various sizes and in some cases double ended.

The sharpening of centre bits is done with small half round files, the spurs, nickers and cutters being filed to a keen edge. Very little can be done with damaged screw points, so every care must be taken to house them in cloth rolls or divided boxes.

A series of holes all of the same depth are more conveniently bored with the aid of some form of depth gauge. Manufactured depth gauges are available which can be adjusted to any required

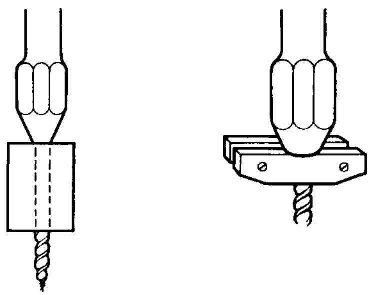


FIG. 7.3. Depth gauges to ensure equal depth of holes.

depth. For the occasional use the bit can be marked with ink or chalk, or adhesive tape can be wrapped round at the required position. More accurately, use a piece of square timber bored with the required bit and cut to the requisite length as shown in Fig. 7.3. A more useful idea suitable for any size bit can be made from two wooden checks with Vee grooves which are held in position by screws or wing nuts and bolts.

Wheel Brace

The wheel brace (Fig. 7.4) which will only take round shanked bits is used mainly with twist drills to make small holes, especially those for screws. The common size brace which is suitable for drills ranging from 2 mm ($\frac{1}{16}$ in.) to 6 mm ($\frac{1}{4}$ in.) has a chuck with spring loaded self-centring jaws. The drill is secured or released by holding the chuck in one hand and turning the wheel with the

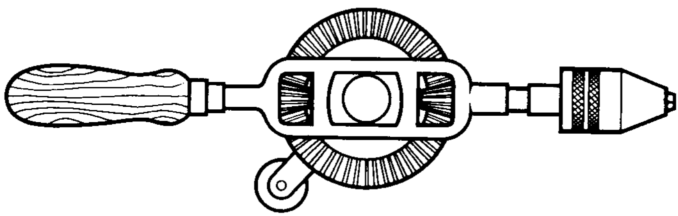


FIG. 7.4. Wheel brace for use with twist drills.

other. For accurate location of the drill on to the work, it is best to centre punch first as in metal work. Holes are drilled continuously through the wood without need for reversal, but because of the rapid feed of the drill care must be taken when drilling blind holes not to drill beyond the required depth. When withdrawing a drill from the hole, continue turning the drill in the same direction, but at the same time pulling vertically, taking great care with small drills which are easily broken.

Wheel braces can be used vertically and horizontally and either of the two handles may be unscrewed if they in any way restrict the use of the tool.

Very small holes can be drilled by fitting a panel pin or veneer pin into the chuck and using it as a drill. Small holes are often made with diamond pointed drills fitted into an archimedian drill and similar ones are included in the bits for a spiral ratchet screwdriver.

Bradawl

The boring of small holes for screws and nails is often more conveniently done with a bradawl (Fig. 7.5). This has a chisel-like point and is used with the flat across the grain of the wood and is given only short turns in each direction. The hand fits comfortably over the handle, but the forefinger must lie down the length of the blade to prevent it breaking, especially when being removed.

The gimlet also shown in Fig. 7.5 is another small boring tool which has spiral flutes with screw point and is often convenient for making screw holes.

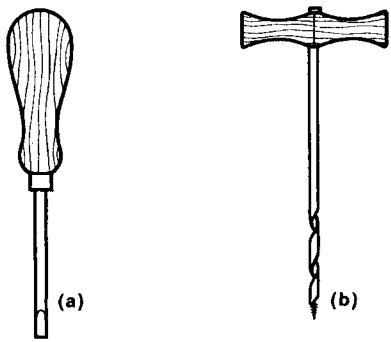


FIG. 7.5. (a) Bradawl for making small holes for screws and nails.
(b) Gimlet for making holes for screws.

Power Drill

The power drill shown in Fig. 7.6 is essential for any workshop, whether it is used with attachments or not. It is specified according to chuck size, that is 6 mm ($\frac{1}{4}$ in.), 8 mm ($\frac{5}{16}$ in.), 9 mm ($\frac{3}{8}$ in.) and 12 mm ($\frac{1}{2}$ in.) which are the limiting sizes of drills that the chuck can hold. Because of this limiting size the drill is restricted to small size holes, but with or without a drill stand, it can be used quickly and efficiently on a vast range of materials including wood, plastics, metal and asbestos sheeting.

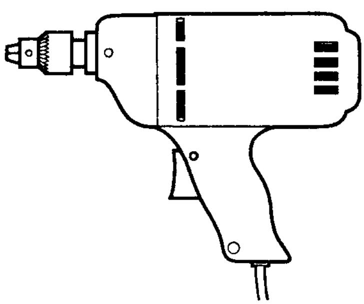


FIG. 7.6. Power drill.

Chapter 8

Cramps and Holding Devices

CRAMPS are used for holding glued joints and parts together while the glue sets, or for holding work steady while some operation is carried out.

Sash Cramp

The sash cramp is the most important cramp and is used for holding together box constructions, frame constructions, jointed boards and other glued parts until the glue sets (Fig. 8.1). The cramps are obtainable in 0·6 m (2 ft) to 2·1 m (7 ft) lengths and consist of either a flat bar or T-section bar fitted with two jaws, one of which is held by a steel peg fitting into one of the spaced holes, while the other is movable but controlled by a screw. In

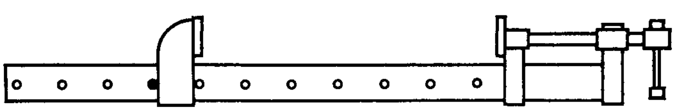


FIG. 8.1. Sash cramps necessary for securing frames when glued.

some types the flat bar has a serrated edge to which the sliding jaw is held by a wedge ratchet and makes the cramp easily adjusted. It is possible by removing the sliding jaws from two peg-type cramps and rejoining them, to form one long cramp.

A set of cramp heads can be purchased which can be fitted to a wooden bar of any length.

When using cramps, small parallel pieces of wood should be used between the jaws and the work to protect the work surface. When assembling box and frame constructions, careful checking for squareness and winding are necessary and the position of the cramps can be adjusted until the work is true. When cramping angled joints, wedge pieces should be inserted between the work and the jaws so that the cramp is holding parallel sides (Fig. 8.2). If the wedge pieces tend to slip, strips of folded glass-paper should be inserted between the wood surfaces.

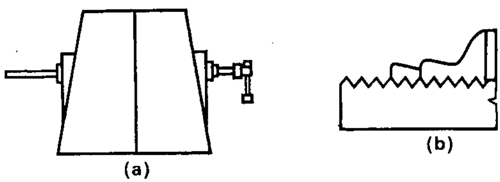


FIG. 8.2. (a) Using sloping blocks to keep the jaws parallel. (b) Ratchet wedges to hold the movable jaw.

Sash cramps are often used for holding wood to be worked, as for example, small pieces requiring grooves or rebates cannot be held in the bench vice because the plough or fillester plane fouls the vice cheeks. The work can be fixed lengthwise between the jaws of the cramp which is then held in the bench vice together with a wooden distance piece as shown in Fig. 8.3.

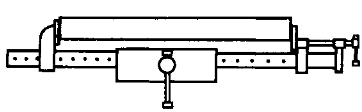


FIG. 8.3. Using cramps for holding pieces which cannot be worked in the bench vice.

G-cramps

These are shaped as the name suggests and are used for holding small glued parts, or for holding work to the bench. They are obtainable in various sizes from 50 mm (2 in.) to 300 mm (12 in.)

which is the limiting size of work that they will hold. The screwed jaw often has a ball socket so that it can be used on angled and irregular work. There are many ways in which a G-cramp can be used, such as securing work to benches, for positioning work to be screwed and for securing equipment in laboratories. An example of its use is shown in Fig. 8.5.

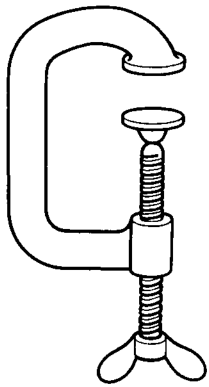


FIG. 8.4. The G-cramp used for cramping glued pieces.

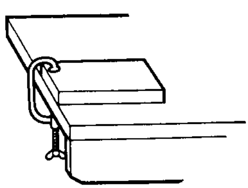


FIG. 8.5. Shows how the G-cramp is used for holding work.

Hand Screw

The hand screw illustrated in Fig. 8.6 is a very old type of cramp that has lost favour because of its easily damaged wooden screw, but it is extremely useful for holding over a wide area. The wooden screw should be coated with graphite to help ease the

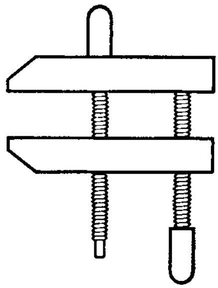


FIG. 8.6. The hand screw which has much deeper jaws.

strain on the threads. The engineer uses a similar but smaller form of this cramp in the toolmakers' cramps and these can often be used with advantage for holding small parts.

Corner Cramps

For mitred joints, especially picture frames, corner cramps are used, but are often restricted to quite small work (Fig. 8.7). For large mitred corners it is best to glue on corner ears and use sash cramps or G-cramps.

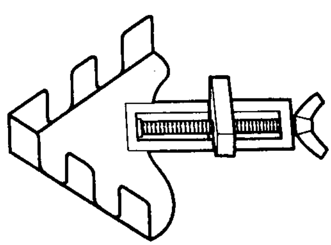


FIG. 8.7. Corner cramps for mitred frames.

Cramp Dogs

Cramp dogs are rectangular bent pieces of steel with tapered points so that when used on the ends of glued boards, the joints are tightly closed (Fig. 8.8).

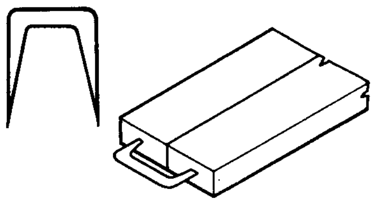


FIG. 8.8. Cramp dogs for holding glued boards.

Holdfast

To hold work firmly to the bench a holdfast may be used (Fig. 8.9). The main pillar drops into a hole bored in the bench top and the screw tightens the shoe on to the work.

Mention should be made of the old German cabinet bench with its end vice and steel spring stops for holding work. Unfortunately it lost favour, but the idea is now returning in some of the newly designed Swedish benches.

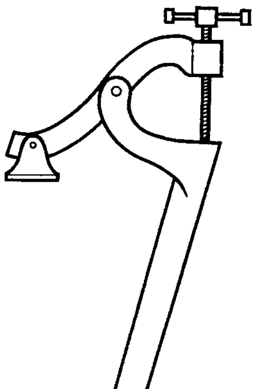


FIG. 8.9. A holdfast used for securing work to the bench.

Improvised Cramps

There are many ways in which cramps can be improvised when suitable cramps are not available, and some ideas are briefly set out and are illustrated in Fig. 8.10.

For flat surfaces, heavy weights, including buckets of water, are effective when loaded on to a flat board.

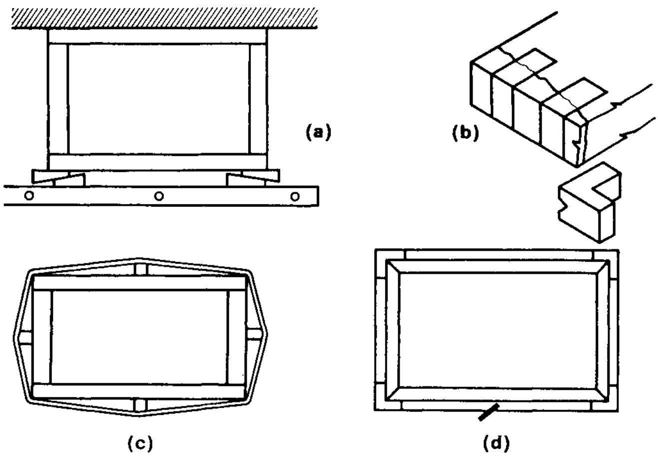


FIG. 8.10. Improvised cramps. (a) Folding wedges. (b) Self-adhesive tape may be used for small repair work. (c) A cord and blocks for cramping glued frames. (d) Blocks and tourniquet for mitred frames.

Frames can be efficiently cramped between battens secured to the bench or floor using folding wedges to apply pressure.

Battens can be bored with holes at intervals to take wooden or metal pegs and thin wedges.

Wooden jaws can be fitted with coach bolts and wing nuts.

Strong cord can be used around a frame and tightened with blocks, while a similar method with string is suitable for small mitred corners.

Small spring clips, bulldog clips, spirals from upholstery springs and clothes pegs can often be used for small work.

Small repair work can be held in place with self-adhesive tape.

Chapter 9

Drawing

A DRAWING is an essential part of any constructional work whatever the material and because of the many conventions used drawing becomes the shorthand of the craftsman's language. Although the technician may not be a draughtsman, he must have a basic knowledge of drawing in order to convey his ideas to others and also to interpret other people's ideas.

Drawing should be done on a suitable board to which the paper is held firmly by clips or draughting tape. A tee-square, 45° and 60° set squares, a good compass and HB and 2H pencils are the basic tools needed.

A good drawing should have clear firm lines with all light construction lines removed. Dimension lines are drawn thinly and are terminated by thin arrow heads and the dimensions are placed above the line, although in many drawings dimensions are still placed in between divided lines. It is conventional to write all sizes up to 1 m in mm and beyond that size in decimal fractions of a metre. Horizontal measurements are placed so that they are read viewed from the bottom of the drawing and vertical measurements are read viewed from the right-hand side of the drawing.

Hidden lines are indicated by broken lines of equal dashes and centre lines are drawn with broken lines, using alternate long and short dashes.

All lettering and figures should be neat, simple and preferably vertical.

Drawings are often made full size, but where the size of the object makes this impracticable, then a scale drawing is made, that is to say, the object is drawn larger or smaller than the original but each part is drawn in exactly the same proportion to the original. The scale may be expressed in fractional form as Scale: $\frac{1}{2}$ full size or in dimensional form as Scale 1: 2 (Fig. 9.1).

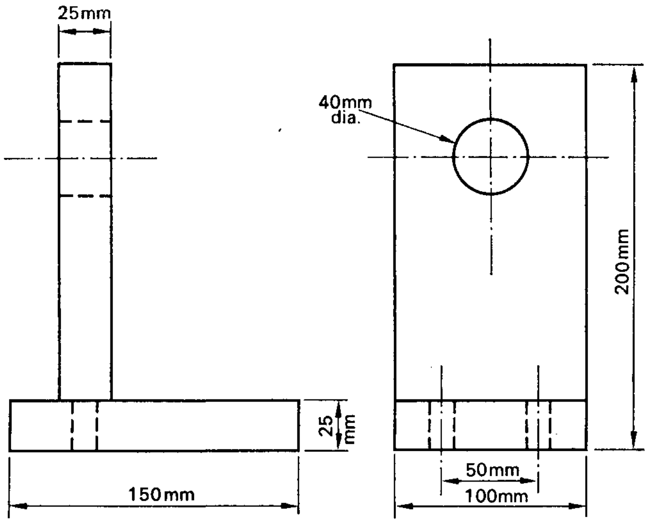


FIG. 9.1. A typical drawing.

Geometrical Constructions

These are essential for accurate drawing and some useful ones are briefly set out below.

To bisect a line AB

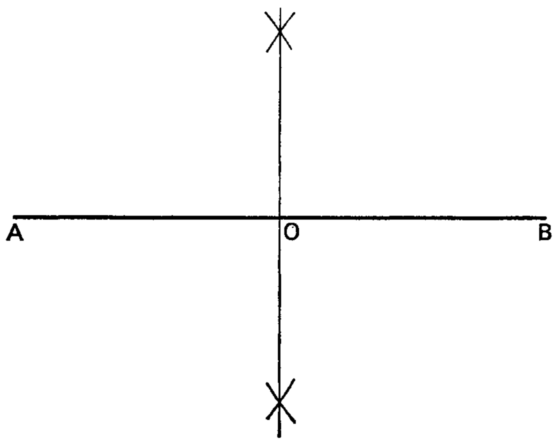


FIG. 9.2.

With centres A and B and with any radius greater than half AB, describe arcs to cut each other on both sides of the line. Join the points of intersection to cut AB at O.

To divide a line AB into a given number of parts (5)

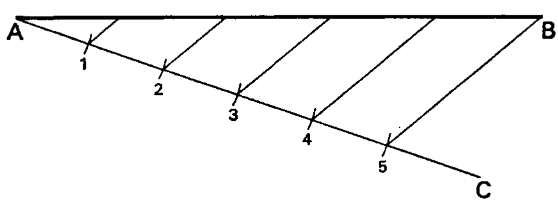


FIG. 9.3.

Draw AC at any angle to AB, and a convenient length. Step off five equal divisions along AC. Join B to 5 and draw parallels through 1, 2, 3 and 4 to divide AB into five equal parts.

To bisect angle BAC

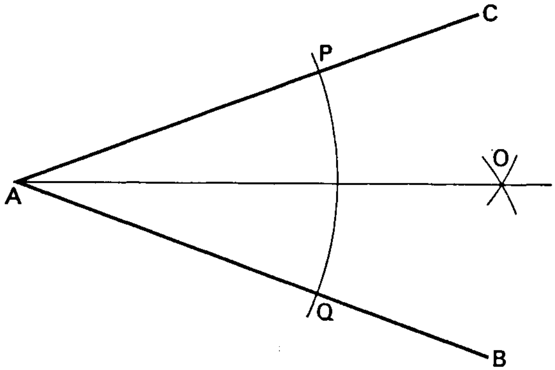


FIG. 9.4.

Draw any arc to cut *AC* and *AB* at *P* and *Q*. With centres *P* and *Q*, draw arcs to intersect at *O*. Draw *AO*.

To draw a tangent to a circle from a point A

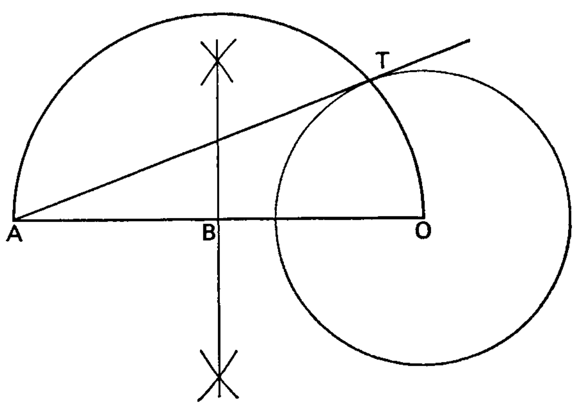


FIG. 9.5.

Join *A* to centre of circle *O*. Bisect *AO* at *B* and with centre *B* and radius *AB* draw a semi-circle to cut the circle at *T*. Draw *AT*.

To draw a circle through three given points A, B, C

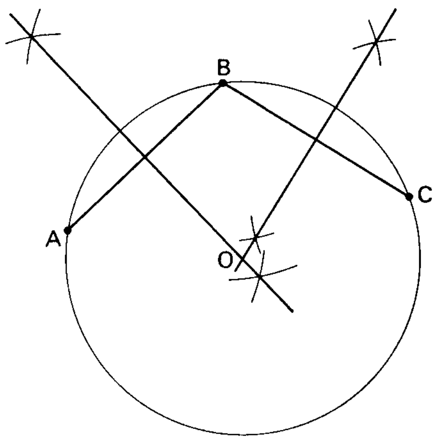


FIG. 9.6.

Join *AB*, *BC* and bisect each line. Let the bisection intersect at *O*. Then *O* is the centre of the circle the circumference of which will pass through the three points.

To draw a circle of given radius to touch two given lines OX, OY

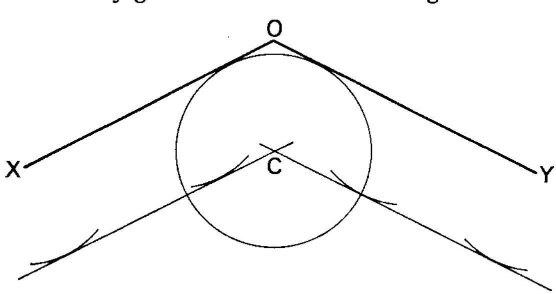


FIG. 9.7.

Draw parallels to *OX* and *OY* at a distance from them equal to the given radius. Let the parallels intersect at *C*. This is the required centre of a circle to touch *OX* and *OY*.

To draw a circle of given radius R_1 to touch a given circle O of radius R and a given line AB

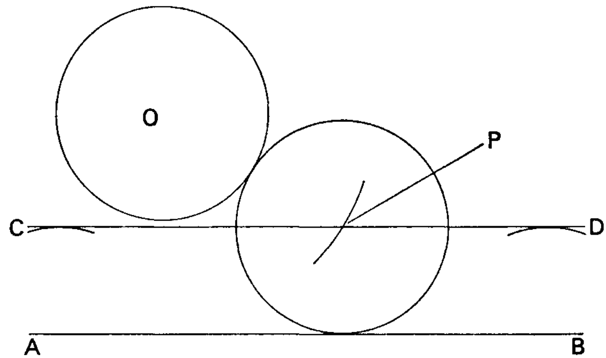


FIG. 9.8.

Draw *CD* parallel to *AB* and at the given radius from it. With centre *O* and radius $R + R_1$, draw an arc to cut *CD* at *P*. *P* is the centre for the required circle.

To draw an arc of radius R tangential to two given circles of radii R_1 and R_2

Case I. With centres *O* and *P* and radii $R + R_1$ and $R + R_2$, draw arcs to intersect at *Q*. This is the centre for the required circle.

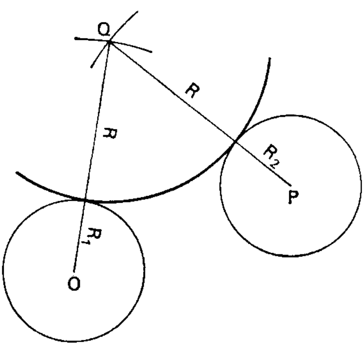


FIG. 9.9a.

Case II. Similarly, with centres O and P and radii $R - R_1$ and $R - R_2$, draw arcs to intersect at Q.

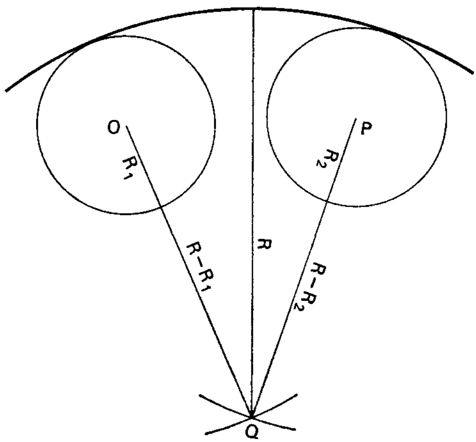


FIG. 9.9b.

To construct a triangle given the three sides a, b, c

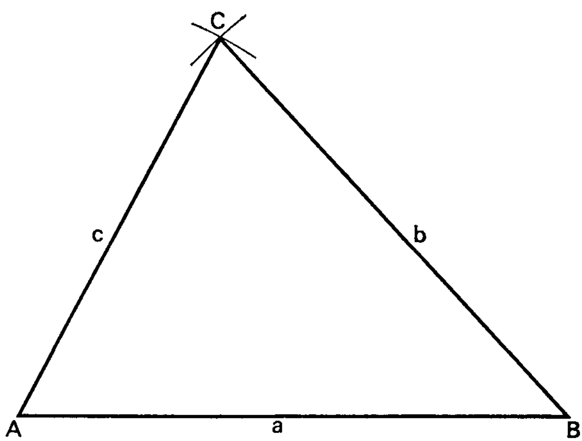


FIG. 9.10.

Draw $AB = a$ and with A and B as centres and radii a and b, draw arcs to intersect at C. Join AC, BC.

To draw a rectangle ABCD given the sides a and b

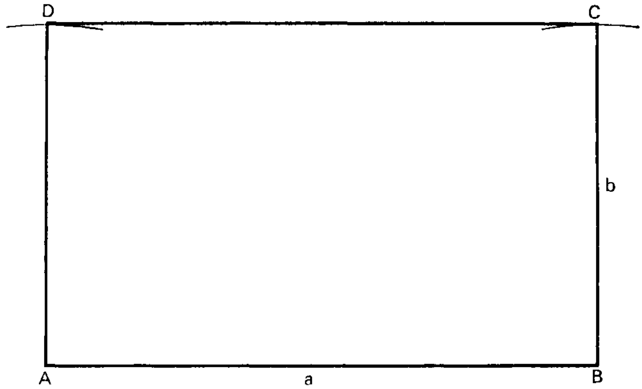


FIG. 9.11.

Draw $AB = a$. With centres A and B and radius b, draw arcs and draw a parallel to AB through D and C. At A and B erect perpendiculars.

To draw a regular pentagon in a given circle

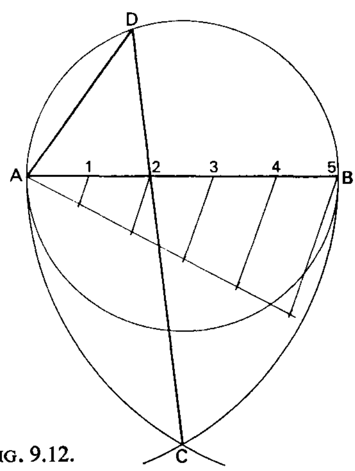


FIG. 9.12.

Draw AB a diameter and divide it into five equal parts. With centres A and B and radius AB, draw arcs to intersect at C. Draw from *C* through the second point to cut circle at *D*. *AD* is the required side of the pentagon.

To draw a regular hexagon in a circle

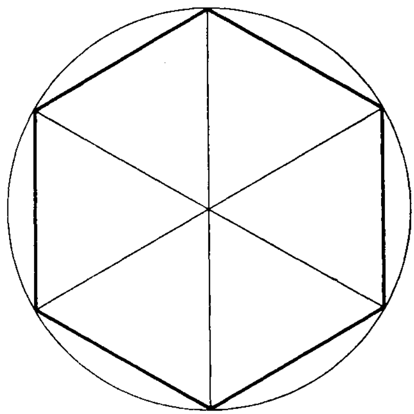


FIG. 9.13.

Using the radius of the circle, mark off six equal arcs around the circumference. Join the six points.

To draw an octagon in a given square ABCD

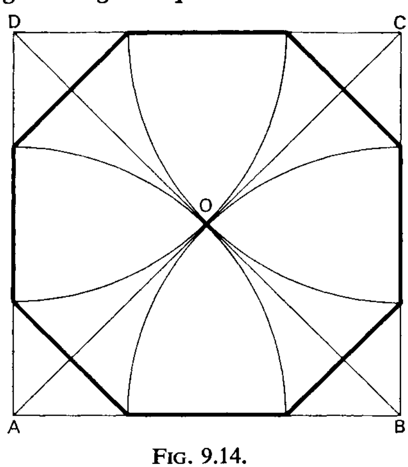


FIG. 9.14.

Draw the diagonals to intersect at *O*. With centres *A*, *B*, *C* and *D* and with radius *AO*, draw arcs each to cut the square at two points. Join the eight points.

To draw an ellipse

Method 1. Insert two pins at the focal points and with a looped string and pencil draw the ellipse.

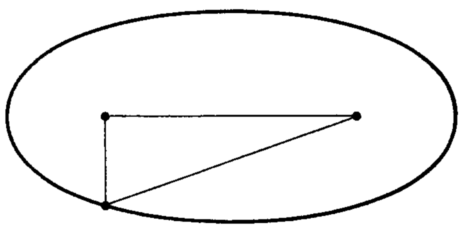


FIG. 9.15.

Method 2. Construct a tramel with *OY* equal to half the minor axis and *OX* equal to half the major axis. Keeping points *X* and *Y* across the two axes, mark a series of points at *O*. Join the points.

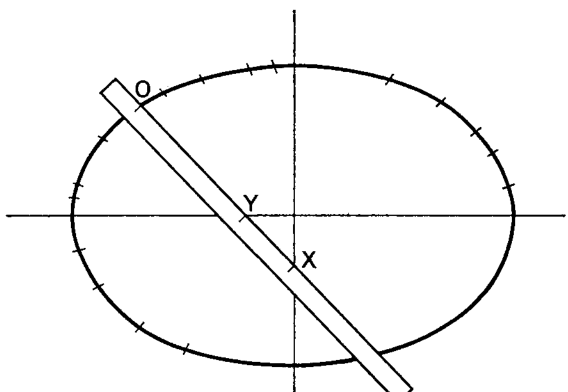


FIG. 9.16.

Method 3. Draw circles with diameters equal to the minor and major axes. Draw a number of diameters and where each cuts the circles, draw vertical and horizontal lines. Join the intersections of these lines.

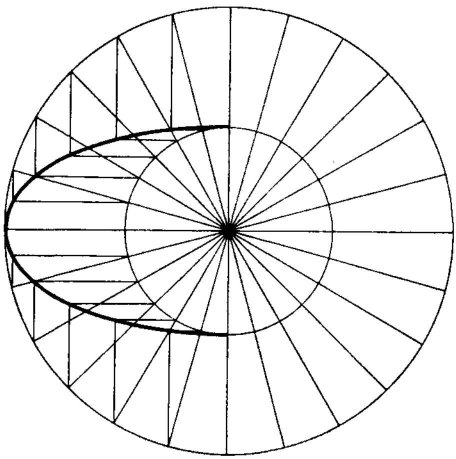


FIG. 9.17.

Orthographic Projection

This type of drawing imagines an object to be positioned in a space bounded by a horizontal and a vertical plane. If the two planes cross each other then four dihedral angles are formed and are called first, second, third and fourth angles (Fig. 9.18). The conventional English method is to place the object in the first angle and the drawing is called "First angle projection". The American method is to place the object in the third angle and is known as "Third angle projection". A drawing in an angle other than first angle must indicate the angle of projection. To increase the usefulness of the drawing, end planes are also introduced. Views are drawn on the various planes by lines thrown or projected from the object to the plane, and it is important to note that the view of the object that the observer sees when he looks towards a particular plane is the view projected on to that plane.

The plane is not a mirror reproducing a reflection and if Fig. 9.19 be studied, the method of projection will be made clear.

If the planes are hinged they can be folded back into one plane as is a sheet of drawing paper and it then represents the conventional method of drawing (Fig. 9.20). The elevation is on the

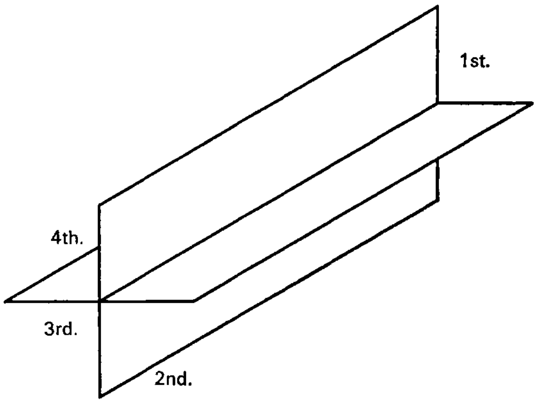


FIG. 9.18. The four dihedral angles.

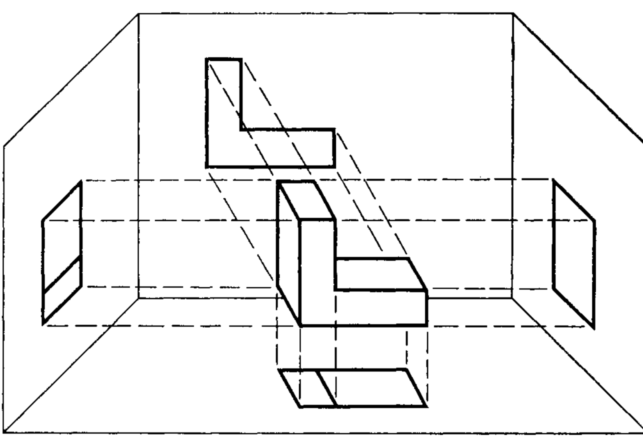


FIG. 9.19. This shows how the four views of an object are projected on to the various planes.

vertical plane, the plan is projected immediately below and end views are projected to one or both sides, but generally only a view from the left is projected, and that to the right of the front elevation. Because the end plane is rotated about the vertical plane, so the projected lines rotate 90°. Thus, when lines are projected from the end elevation to the plan, or vice versa, lines are first projected at right angles to the *XY* line and then with *O* as centre, quadrants are drawn to *X′ Y′* and then the lines projected at right angles. Note that it is often more convenient for the object to rest on the horizontal plane.

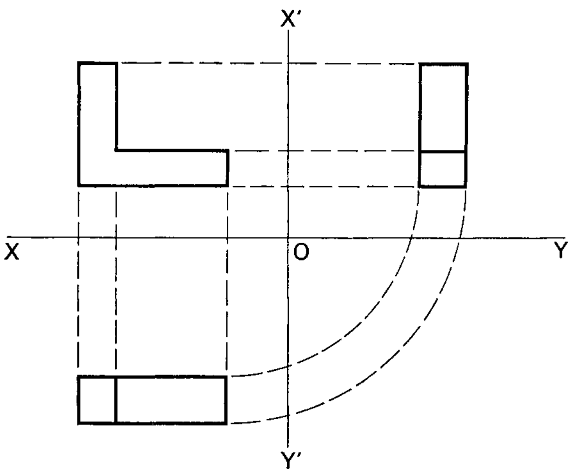


FIG. 9.20. How the projections appear as a drawing.

To make an orthographic projection, first make a rough plan of the overall size so that the *XY*, *X′ Y′* lines can be conveniently positioned, because they need not necessarily be in the centre of the paper. Draw the front elevation first and then the other two views in any order, or simultaneously, whichever is more convenient.

One of the difficulties of this type of drawing is to visualize the solid shape of the object. Consider the simple drawing in Fig. 9.21

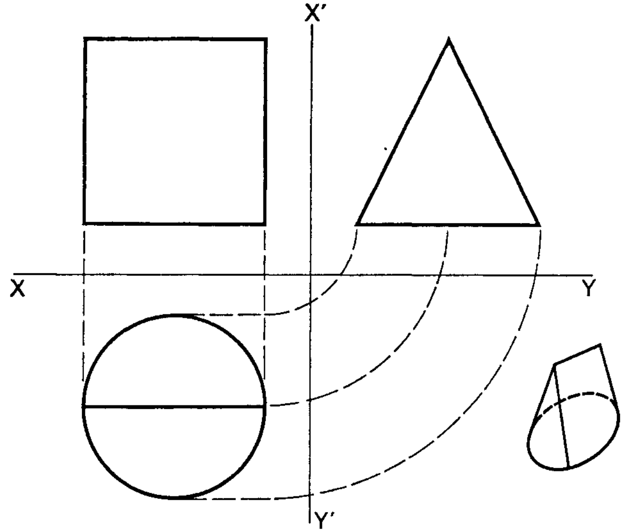


FIG. 9.21. What is it?

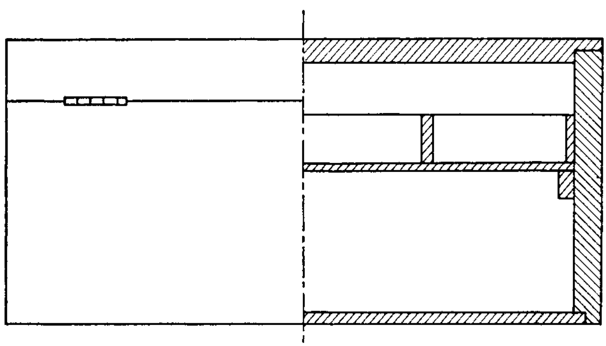


FIG. 9.22. A drawing of a box showing hidden detail.

where the front elevation is a rectangle, the end elevation a triangle and the plan a circle with a diameter. The object is a triangular section cut from a cylinder.

All hidden parts are shown by dotted lines, but often in order to reveal hidden detail, a sectional or half sectional view is made (Fig. 9.22).

Pictorial drawings are of three types; Isometric, Oblique and Perspective, and it is this type of drawing in sketch form that is most useful for the technician.

Isometric Drawing

This method shows three views in one drawing and in it all vertical lines are vertical and all horizontal lines are drawn at 30° to the horizontal. The length of all lines are drawn as true lengths and because of this and the fact that all lines are parallel, the drawing appears somewhat out of shape (Fig. 9.23). If sloping

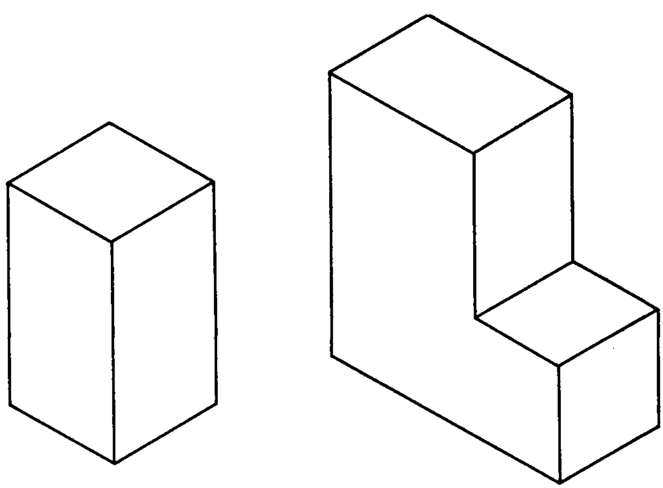


FIG. 9.23. Isometric views of simple objects.

lines are not readily completed, draw the isometric of the containing rectangle and complete from these (Fig. 9.24).

The isometric of a circle can be done in a number of ways as is shown in the isometric of the cube in Fig. 9.25. In all cases it is necessary to draw the isometric of the square containing the circle.

In case (a) the diameter of both the isometric and geometric squares are divided into the same number of equal parts. The points are numbered and at each one perpendiculars are erected.

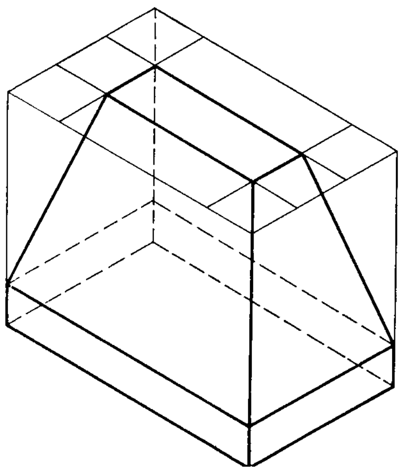


FIG. 9.24. How sloping lines are formed from the containing rectangle.

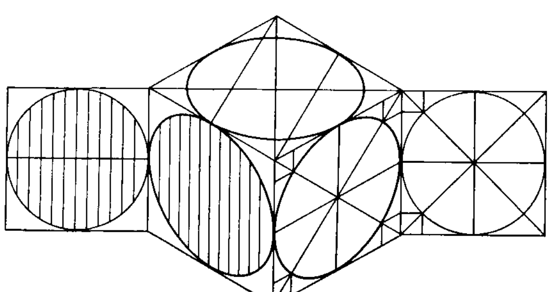


FIG. 9.25. Three methods of drawing the isometric of a circle.

The lengths of the perpendiculars of the geometric circle are then transferred to the corresponding perpendiculars of the isometric square and a smooth curve drawn through the resulting points.

In case (b) diameters and diagonals are drawn to both squares. The geometric circle is drawn and the corner squares constructed. These distances are transferred to the isometric square and small isometric squares are drawn in each corner and a curve is drawn through the eight points.

In case (c) a method using a compass is shown.

Oblique Projection

Oblique projection is similar to isometric, but uses a true elevation as one view and the second view is made at any convenient angle, very often at 45°. It has the advantage that any circles or curves can be shown correctly in the front face (Fig. 9.26).

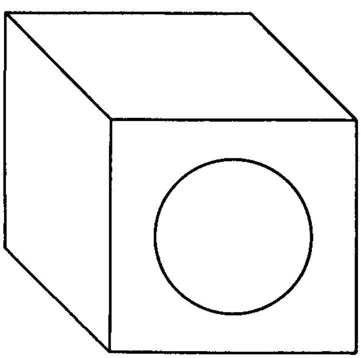


FIG. 9.26. An example of oblique projection.

Perspective Drawing (Fig. 9.27)

This gives a true artistic view of the object and in it vertical lines are always made vertical, but horizontal lines are made so that they will eventually meet at a vanishing point.

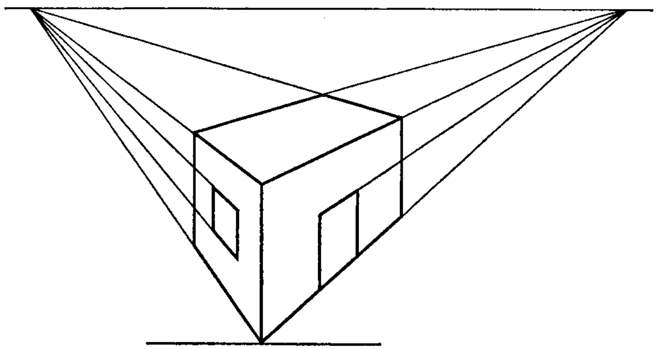


Fig. 9.27. A simple perspective drawing.

Chapter 10

Jointing

THE successful construction with wood depends on satisfactory joining. Joints have been used since very early times and their form has been evolved by craftsmen of many trades and ages. Because of modern man-made materials and modern adhesives and fixings, a certain amount of simplification is possible without causing loss of strength. Joints can be divided into three main groups: (a) those used in the construction of frames; (b) those used in the construction of boxes and (c) those used for increasing the size of timber. These three main groups of constructions will employ the use of butt joints, housing joints, lapped joints, notched joints, mortise and tenon joints, dowel joints and dovetail joints.

Butt Joints

The butt joint (Fig. 10.1) is the simplest form of all the joints and although it is held together by nails, screws or glue, the accurate making of the butt surface will increase its efficiency. The joint can be used for frames, boxes or for joining angled or mitred parts. In every case the end grain of one part must be sawn or planed true to fit the other. A good saw cut will produce a suitable surface, otherwise the butt surface must be planed square, preferably on a shooting board. The joint can be secured with nails or other fastening or with the addition of glue. Modern adhesives give good adhesion between end grain and long grain which the older type glues failed to do. In order to hold pieces to be nailed, hold one piece in the vice and support the other piece

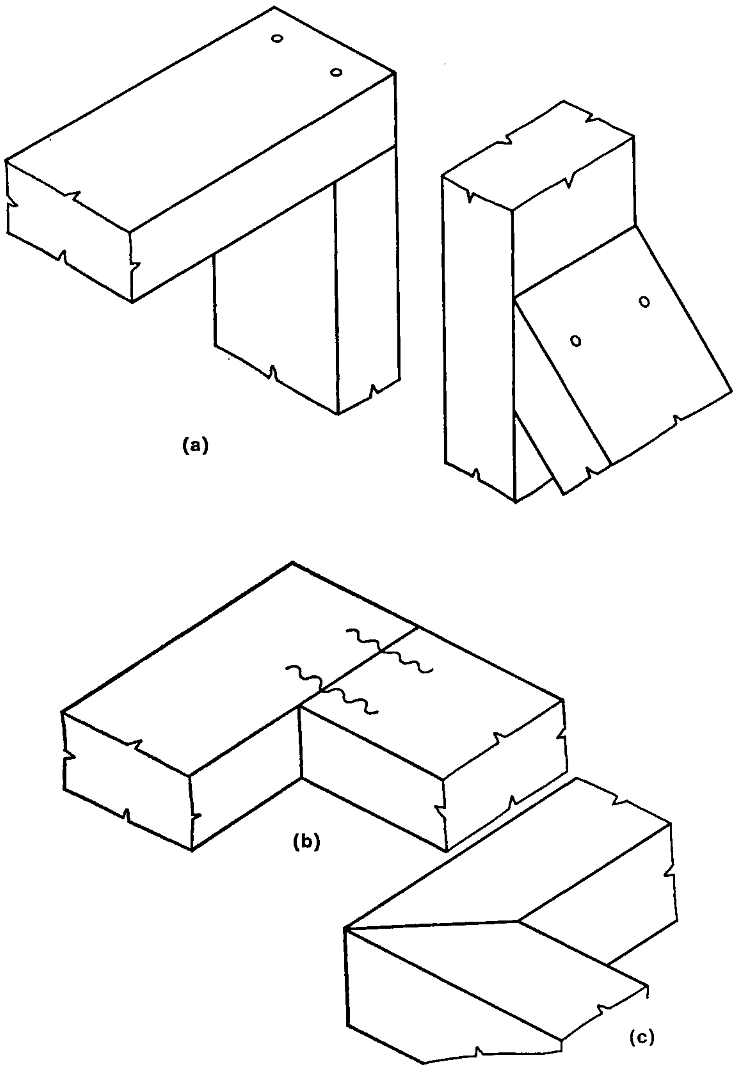
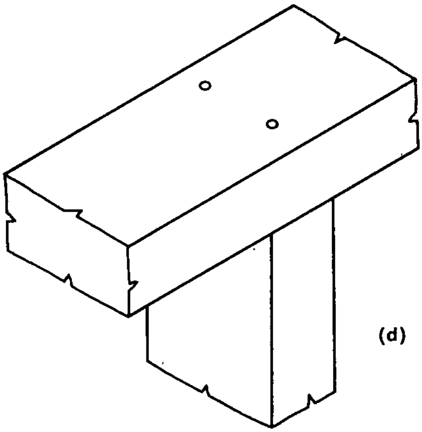


FIG. 10.1. Examples of butt joints fixed with nails.



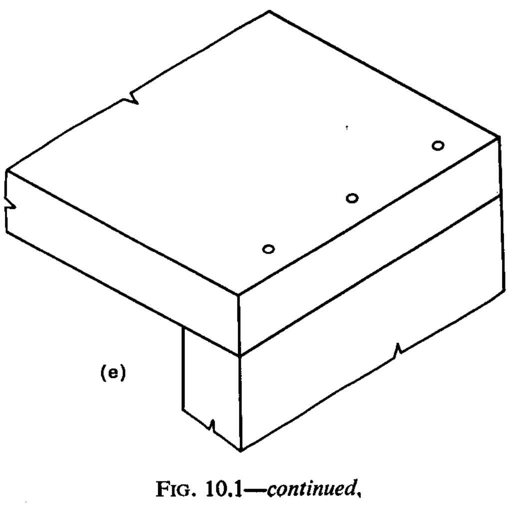


FIG. 10.1—*continued*.

on a block as in Fig. 10.2, thus leaving both hands free to hold the work square. Wide boards need a temporary strip to locate the work (Fig. 10.3).

Boards which are to be joined should be planed square and straight, either separately or both pieces together in the vice or on a shooting board. The pieces are glued and rubbed together by supporting them in the vice and, with the thumb and fingers, sliding one piece over the other to squeeze out air and surplus glue (Fig. 10.4). The boards can also be glued and held in sash cramps.

Simple butt joints can be strengthened by the addition of glued blocks or fillets, metal angle brackets or metal or plywood plates fixed across the corners (Fig. 10.5).

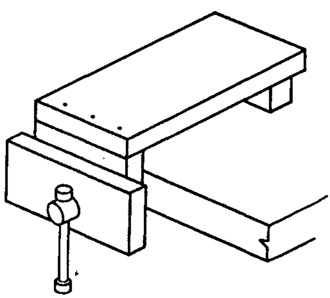


FIG. 10.2. How to support pieces when nailing.

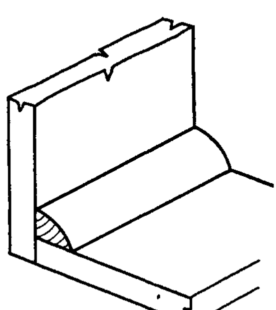


FIG. 10.3. A corner fillet is used for a wide butt joint.

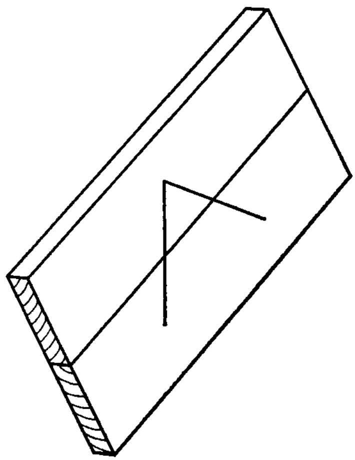


FIG. 10.4. Two boards butt jointed and glued.

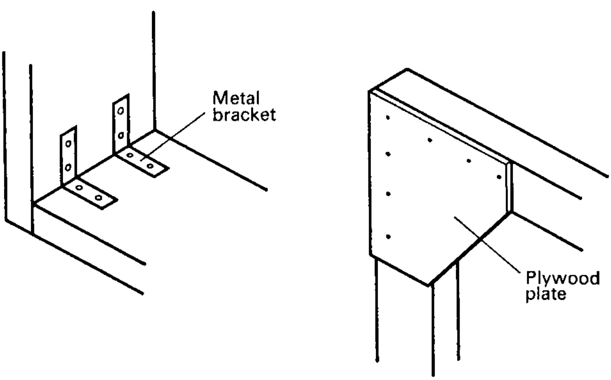


FIG. 10.5. How to strengthen butt corner joints.

For door construction, where a skin of hardboard or plywood is to be glued and pinned on both sides, simple butt jointing with a good adhesive or with corrugated fasteners is adequate. When constructing doors in this fashion take into consideration the fixing of handles, hooks, etc., and arrange the position, or the addition of rails to accommodate such fittings.

Halving Joint

The efficiency of jointing is improved by increasing the number of glued surfaces that are in contact with one another. The simplest method is by means of the halving joint and these are shown combined in a frame and are known as end-halving, T-halving and cross-halving (Fig. 10.6). The marking out of any joint must be accurate and where marking out the size of one piece of wood on to another is involved, then the piece in question should be used where possible to mark the corresponding size.

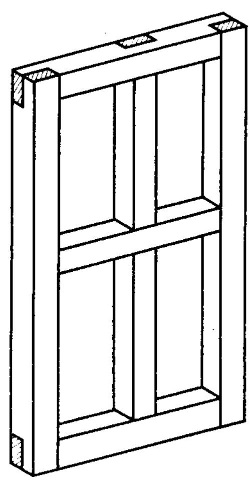


FIG. 10.6. A frame made with various halving joints.

The halving joint shown in detail in Fig. 10.7 is marked out with a marking knife and try square for the shoulder lines, and with a gauge set to the dead centre of the thickness for marking the halving. The tongue of a halving is cut by holding the piece in the vice, sawing down vertically on the waste side of the line to the shoulder (Fig. 10.8). (It is most important for this and every other kind of joint that saw cuts are made on the waste side of a line.) The work is then held in a bench hook and sawn horizontally on the waste side of the shoulder line to leave a half thickness tenon.

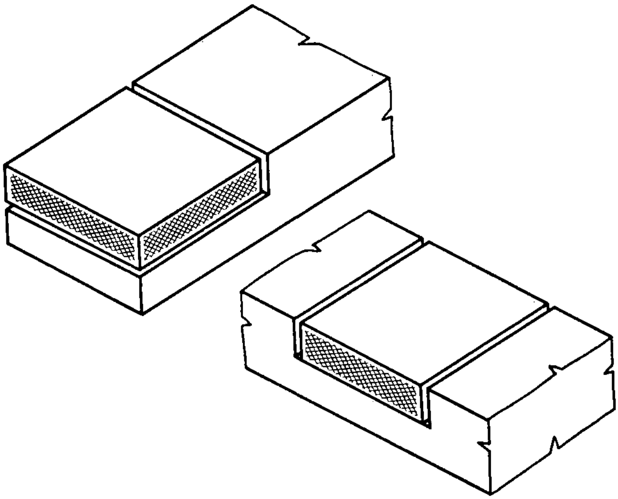


FIG. 10.7. The halving joint.

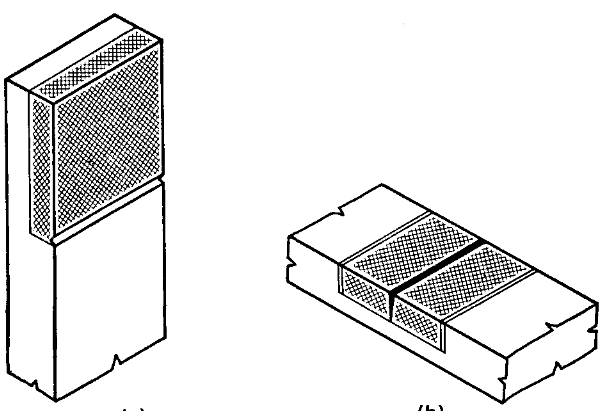


FIG. 10.8. Stages in cutting a halving joint showing gauging and sawing.

The socket or open mortise is cut by holding the work in the vice and making saw cuts on the waste side of each line down to the halving mark. A further cut is made in the middle, thus breaking up the fibres to ease the cutting of the waste and preventing any splitting. The waste wood is removed with a chisel working from each side upwards towards the middle and then finally paring with a chisel held flat to make a level surface at the bottom of the socket. It is emphasized here that both hands hold the chisel behind the blade. A good halving joint needs to be accurately made so that it can be glued together with the final external surfaces level. The joint can be additionally held with nails or screws.

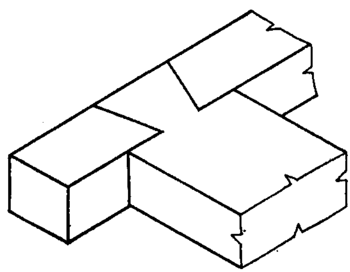


FIG. 10.9. Dovetail halving joint.

The three halving joints are a combination of these two processes. Often the dovetail is employed to strengthen a halving joint and, as can be seen from the illustration, has tremendous holding power in the horizontal direction (Fig. 10.9).

Housing Joint

The housing joint is used where one member fits at an angle to another member. The most common use of this joint is in the construction of shelving, but there are many variations of it both in joinery and cabinet making.

To cut a housing joint illustrated in Fig. 10.10, mark out carefully and gauge to depth about one-third the thickness of the wood. Saw to depth on the waste side of the line and remove the waste with a chisel. If the length of the housing is longer than the chisel, use the chisel on the reverse side at an angle, the bevel being on the underside. The bottom of the housing is trued with a router set to the correct depth. A stopped housing (Fig. 10.11) makes the joint invisible when assembled. After marking out, chop out a mortise at the front so that the saw can cut to the full

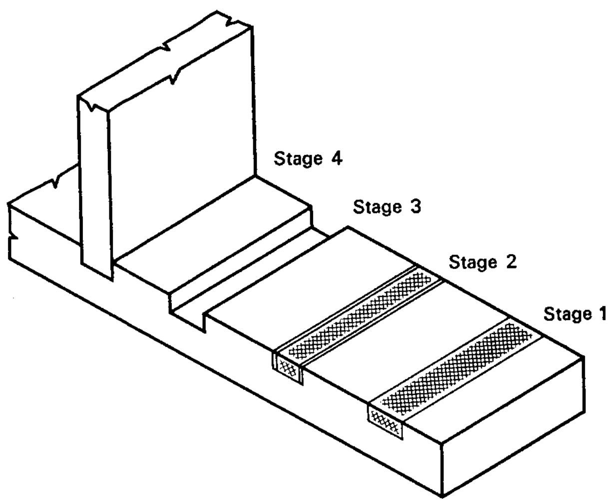


FIG. 10.10. Stages in cutting a through housing joint.

length and depth. Remove the waste with a chisel and a router. The front edge of the shelf must be cut out to fit the front of the housing. The dovetail housing can be varied from a single angle to a double angle and from a parallel to a tapered groove. This is often used in fitting very deep shelves. Illustrated in Fig. 10.12 are other variations which are useful. The so-called "birdsmouth" is a type of housing and is usually used where a sloping member is fitted. In this class of joints can be included the lap joints used in

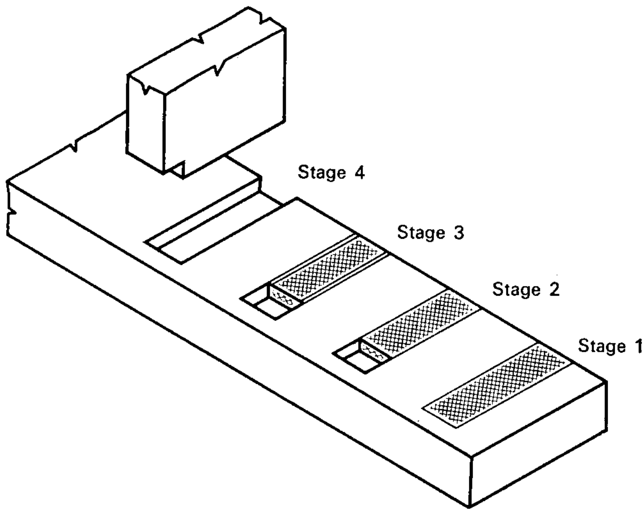


FIG. 10.11. Stages in cutting a stopped housing joint.

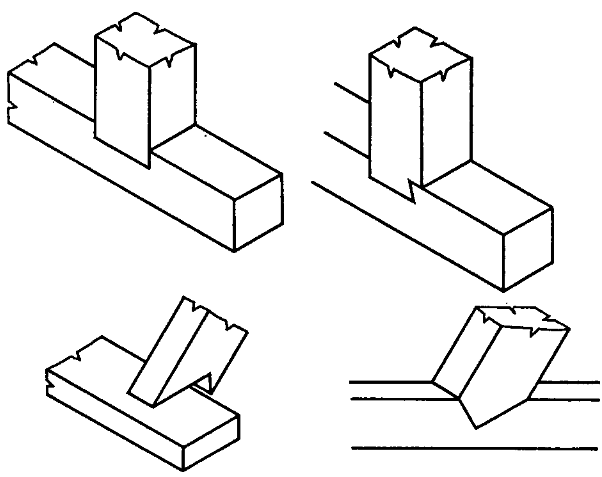


FIG. 10.12. Examples of housing joints.

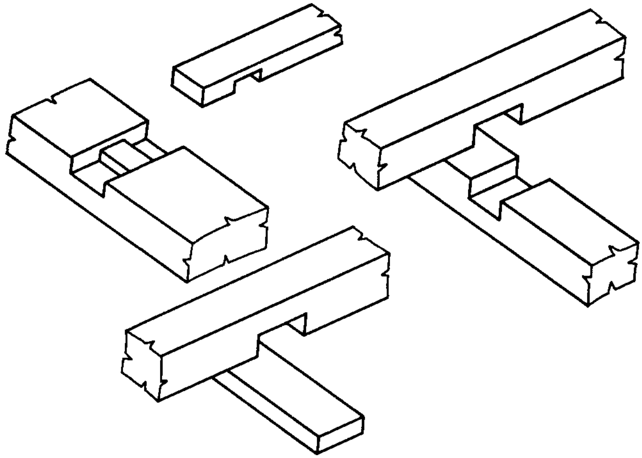


FIG. 10.13. Various notched and cogged joints.

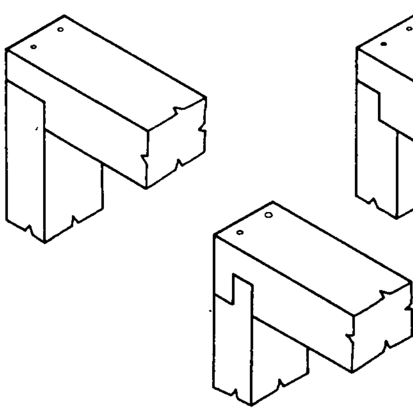


FIG. 10.14. Half lapped and grooved joints.

box construction shown in Fig. 10.14, and notched and cogged joints shown in Fig. 10.13. Notice how each joint increases the number of glued surfaces in contact and hence becomes progressively stronger. To cut the joint, cut the pieces to size square at the ends, mark out with a gauge, saw across the shoulder and

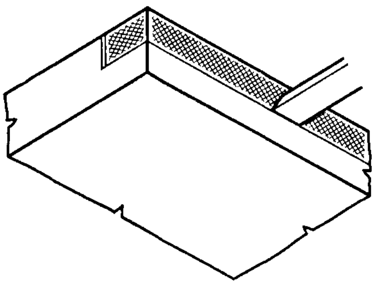


FIG. 10.15. How to cut the end tongue.

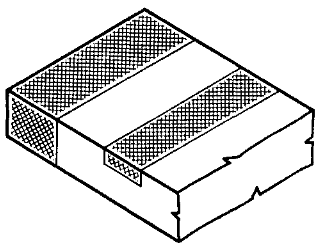


FIG. 10.16. Leaving an extra waste piece when cutting a groove.

then chop down with a chisel as shown in Fig. 10.15. When cutting the groove for the joint, cut the wood sufficiently longer to avoid the short grain breaking (Fig. 10.16). Once the work has been glued, this waste piece can be sawn and planed level.

Mortise and Tenon Joint

The mortise and tenon joint shown in Fig. 10.17 is the strongest joint for any frame constructions, and has been used for hundreds of years for the constructions of doors, windows, chairs, frames and for other interior and exterior work and details for its construction are given in Figs. 10.18 and 10.19. The tenon or tongue fits into a mortise or mouth, and each is made approximately

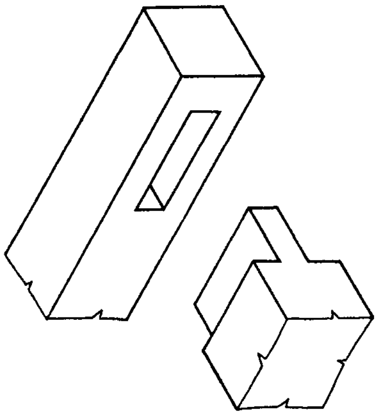


FIG. 10.17. The mortise and tenon joint.

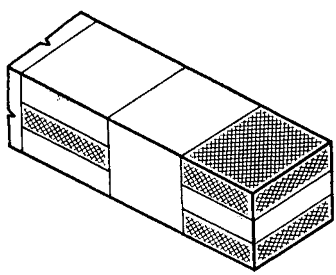


FIG. 10.18. Setting out a mortise and tenon.

one-third the thickness of the wood. The important thing to note is that the gauge is set to a mortise chisel which is nearest to one-third the thickness of the wood, so that the mortise is cut to the width of the chisel and then the tenon is cut to the same size and they should fit. To cut the joint, mark off the shoulder line for the tenon, which will be longer than the width of the wood for a through tenon and two-thirds the width of the wood for a stopped or stub tenon. The exact width of the timber is used for the length of the mortise. The mortise gauge is set to the required mortise

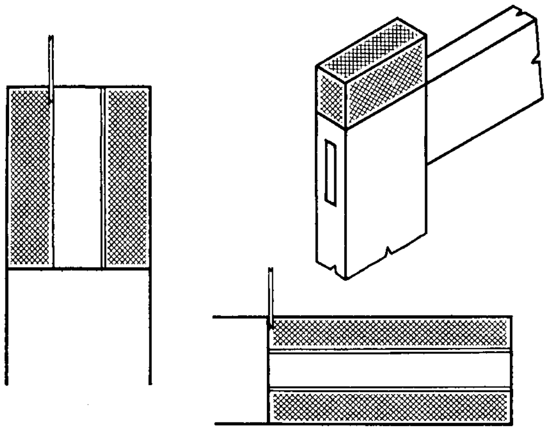


FIG. 10.19. Stages in sawing a tenon.

chisel and both mortise and tenon are gauged. Saw down the tenons to the shoulder lines, care being taken not to over-run them. The easiest way is to hold the work in the vice at an angle and to saw horizontally to make a diagonal cut, reverse, and make an opposite diagonal cut and then with the work held vertically complete the cut. Here it is again emphasized to saw on the waste side of the line. Having made the vertical cuts, saw across the shoulder lines, again on the waste side of the line. The mortise is chopped out with a mortise chisel. Start at the centre making a Vee cut and make subsequent cuts each side of this, clearing the waste at each cut and gradually work deeper and more upright as the ends of the mortise are approached. With a through mortise, chop down to the middle from each side. With a stub tenon mark the chisel to the required depth and take each final cut to this depth. Where the tenon is at the end of a stile, the tenon cannot be made the full width, and is cut down to two-thirds of the width, but in order to maintain the full bearing surface of the shoulders, a square or sloping haunch is made. Because of the danger of the mortise breaking out, being cut so close to the ends, the stile is extended and the "horn" removed after assembly. When tenons fit into a square leg, as in a table, they are given increased strength by mitreing. Through tenons are invariably wedged and the various methods employed are illustrated in Fig. 10.20. This may be done by cutting the mortise larger to form a dovetail shape and then driving in hardwood wedges, or by making two saw cuts in the tenon and driving in thin wedges, both methods converting the tenon into a dovetail. A method used by the cabinet maker is known as a fox wedging. Here the mortise is undercut like a dovetail and the two wedges are fitted into the saw cuts and then the tenon is driven home. No cramps are necessary, but care must be taken in making the wedges the correct length. Sometimes when the wall of the mortise would be left very thin it is best to make a barefaced tenon which along with other variations of the tenon is shown in Fig. 10.21. It is not always necessary to reduce a tenon to a third if there is sufficient wood to make a wider mortise. For very deep rails,

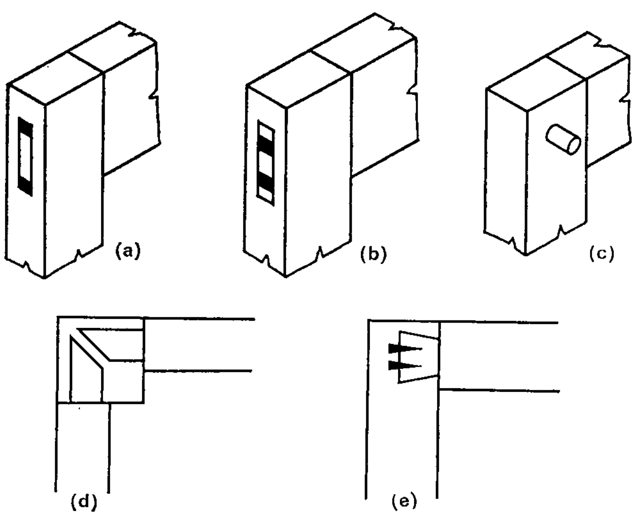


FIG. 10.20. (a) and (b) show methods of wedging tenons, (c) is a draw-bore tenon, (d) mitred meeting tenons and (e) shows fox wedging.

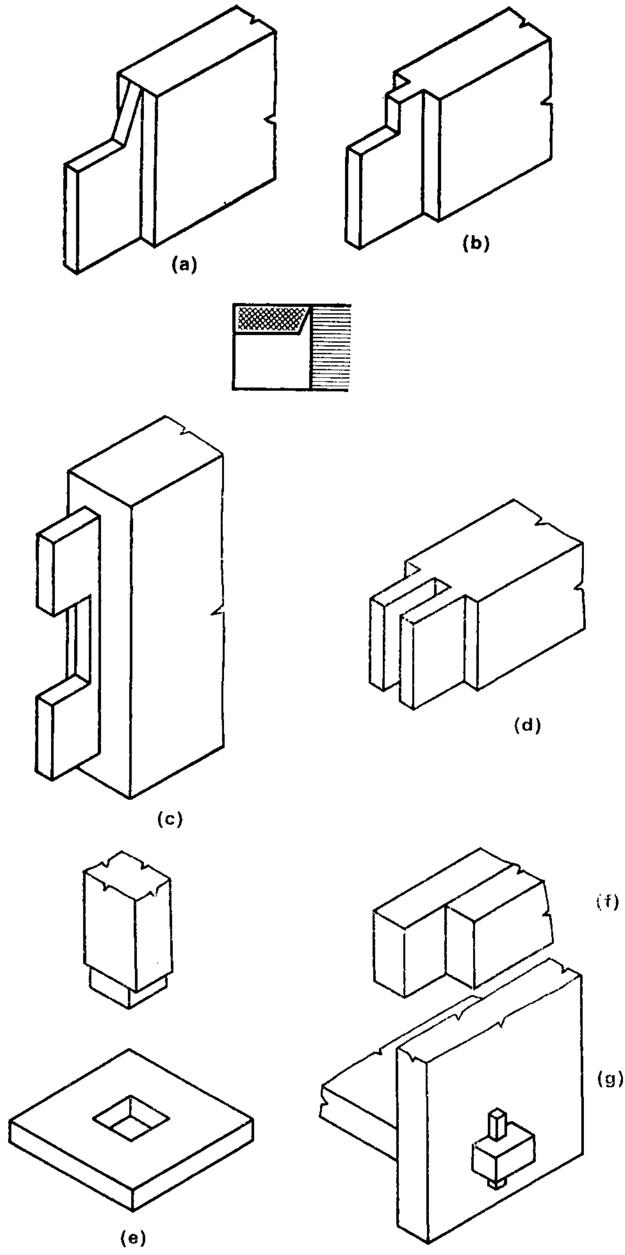


FIG. 10.21. Variations of the tenon. (a) Sloping haunch. (b) Square haunch. (c) Double tenon. (d) Twin tenon. (e) Large square tenon. (f) Barefaced tenon. (g) Tusk tenon.

tenons are cut to form double tenons and this is necessary when constructing doors in which mortise locks are to be fitted. Where mortises and tenons are very wide they are often reduced to form twin tenons. A useful method of fixing a tenon without cramps is to make what is known as a draw-bore tenon. This consists of drilling a hole through the mortise and then to fit in the tenon and mark on to it the position of the hole. A hole is then drilled through the tenon, but with its centre about 2 mm ($\frac{1}{16}$ in.) nearer to the shoulder. When the tenon is glued and fitted, a pointed dowel is driven into the hole and because the holes are offset the tenon is drawn very tightly into the mortise. A wedged tusk tenon is very useful for knock down work.

Often a framework may have a rebate or groove in which panels are fitted. When making the mortise and tenon for this type of frame, allowance must be made in constructing the joint so that no gaps are left. The rebated frame is made with tenons that have long and short shoulders (Fig. 10.22). Having marked out the joint and the rebate, saw down the cheeks of the tenons and chop

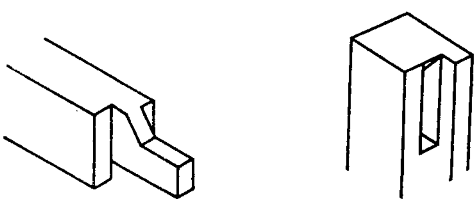


FIG. 10.22. Mortise and tenon for grooved rails.

out the mortises and then make the rebate, finally cutting off the shoulders of the tenons. When fitted it will be seen that the short shoulder fits into the rebate. When a groove is ploughed it makes the tenon narrower and consequently the mortise must be correspondingly reduced and also a square haunch is left at the top to fill in the space left by the grooves (Fig. 10.23).

The bridle joint (Fig. 10.24) is really an open tenon joint and is marked out and cut exactly as a tenon joint, but the best way to

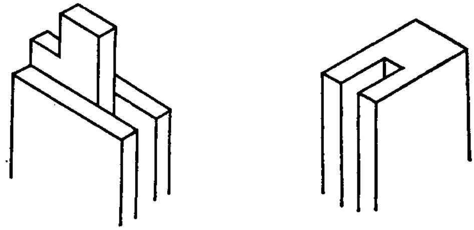


FIG. 10.23. Mortise and tenon for rebated rails.

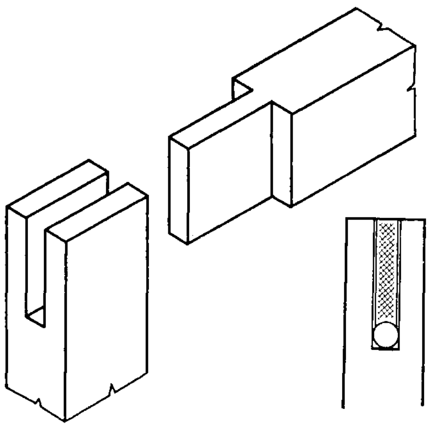


FIG. 10.24. Bridle joint.

cut the mortise is to drill a hole at the bottom of the joint and saw down the cheeks. The whole of the centre core comes away and the bottom of the joint just needs squaring with a chisel.

Dovetail Joint

This is used mainly in box constructions, ranging from small vanity boxes to large cupboards. The dovetail joint is no more difficult to make than any other joint provided it is marked out correctly and cut accurately to the line. Most students shy at making dovetails because of the marking out, but once this has been mastered it becomes a very reasonable joint to make. There are two parts to the dovetail joint, the dovetail itself and the pins, and theoretically they are made of equal size. Machine-made dovetails are equally proportioned, but usually hand-made dovetails are made so that the tails are about two to four times as large as the pins. In craftsman-made drawer dovetails, the pins were only made a saw cut in thickness and this is adequate in a

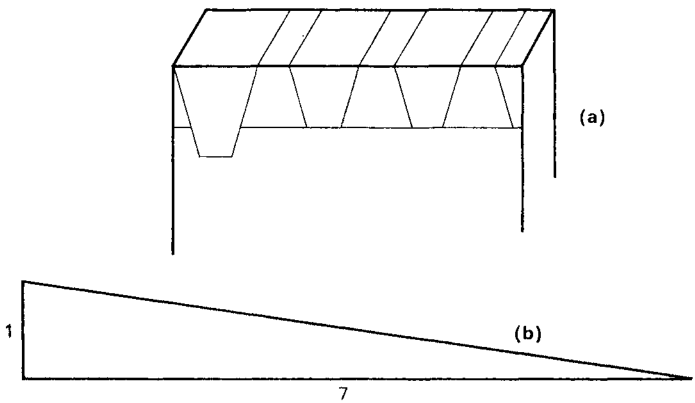


FIG. 10.25. (a) Using dovetail marker. (b) Slope of dovetail.

drawer for the only forces act directly opposing the dovetail. Dovetails do not have a great slope, for if the slope is too great short grain is produced which soon breaks away. For softwoods the slope is 1 in 8 and for hardwoods 1 in 6, but 1 in 7 can be a convenient standard suitable for most joints. The slope is marked with a bevel square or with a special dovetail templet, which enables both the slope and the horizontal line at right angles to be made at the same time. Through dovetails are made slightly longer than the thickness of the timber so that the joint can be cleaned off with a plane after gluing, but with lapped dovetails the pieces are squared to size and shoulder lines gauged. This is best done with a cutting gauge. A suggested method of marking out a set of dovetails is shown in Fig. 10.26: gauge the depth of the dovetail equal to the thickness of the wood; measure in 6 mm (¼ in.) from each side; draw a parallel line on the right; draw a sloping line which can be equally divided into the number of dovetails, draw parallels to the end of the wood; mark 3 mm (⅛ in.)

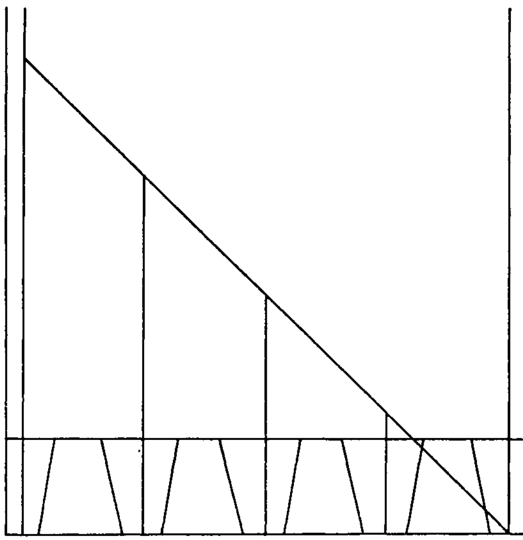


FIG. 10.26. How to set equidistant dovetails.

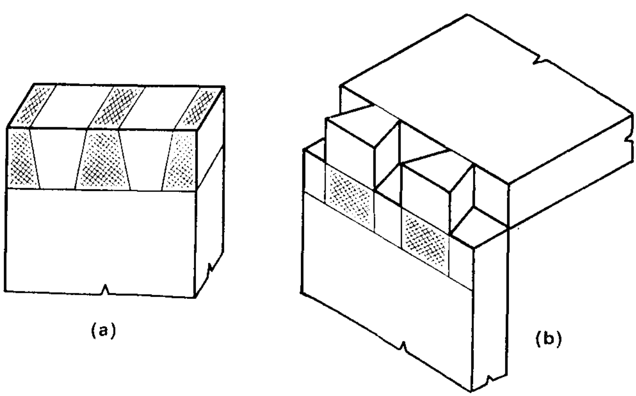


FIG. 10.27. (a) Marking dovetails. (b) Marking pins.

each side of each point; mark the dovetails both on the face and on the end; gauge a line for the depth on the other piece of wood; saw down the dovetails with a dovetail saw, holding the work in the vice so that the lines to be cut are vertical. Now set the other piece in the vice level with a wooden block or plane, rest the tails on the block and on the end of the other piece; use the saw held at the front, and drawing it through the existing saw cuts, mark the shape of the pins and then mark the vertical lines. Make saw cuts on the waste side of the marks. The waste material on both pieces is removed with a coping saw and bevel chisel. Another method of marking is to cut out the dovetails completely and then to mark the pins from them with an awl or sharp knife (Fig. 10.27).

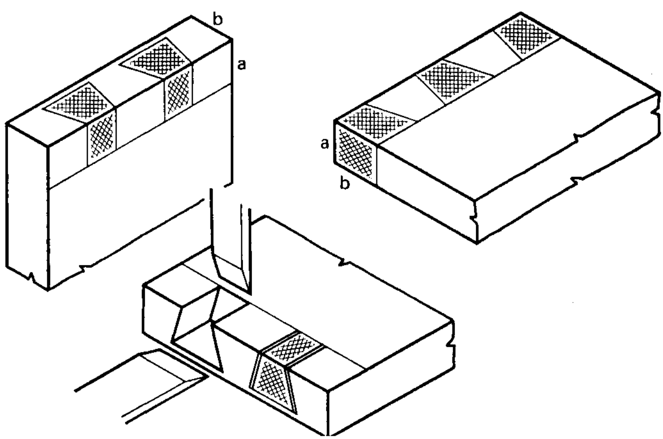


FIG. 10.28. Marking and cutting lap dovetails.

Lap dovetails (Fig. 10.28) are cut in a similar manner, but the removal of waste from the pins is done completely with a chisel chopping both ways. Care must be taken that the shoulders are cut cleanly and squarely. Tap the tails in gently with a hammer.

When cutting mitred dovetails the pins are cut first and the tails marked from them.

Dowel Joint

The dowel joint consists of boring holes and fitting in specially prepared lengths of dowel rods (Fig. 10.29). The joint is marked out with square and gauge and care must be taken to bore the holes vertically. The dowel size should be no more than half the thickness of the wood. The dowel is chamfered at the ends and a shallow saw cut made along its length. The bored holes are slightly

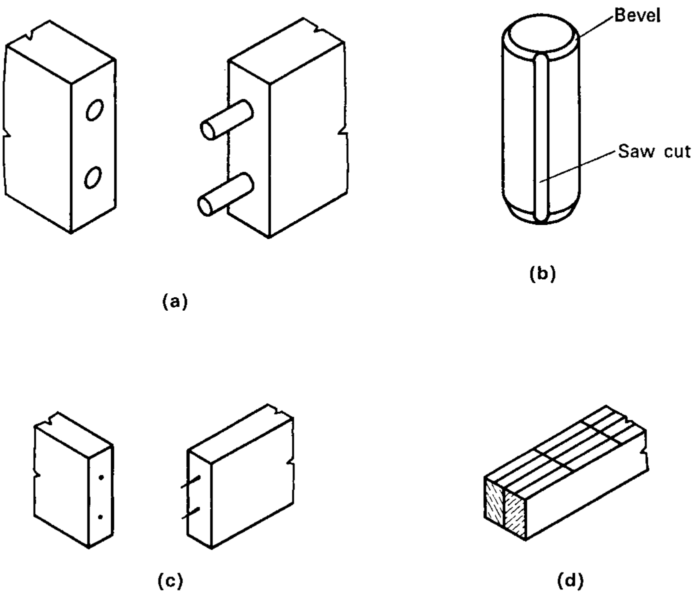


FIG. 10.29. (a) Dowel joint. (b) Dowel with chamfered ends and saw cut along its length. (c) and (d) Methods of marking dowel positions.

countersunk. All these points allow for the excess of glue to escape. Another method of marking dowel positions is to mark out one piece, drive in small veneer pins at the centres, nip off the heads with pliers and then press this piece on to the other to mark the corresponding centres.

Increasing the Size of Timber

To increase the size of timber various methods may be employed as shown in Fig. 10.30. A plain butt rubbed joint can be employed, but in certain cases, such as when using oak or teak, some additional jointing is necessary and this is done by means of

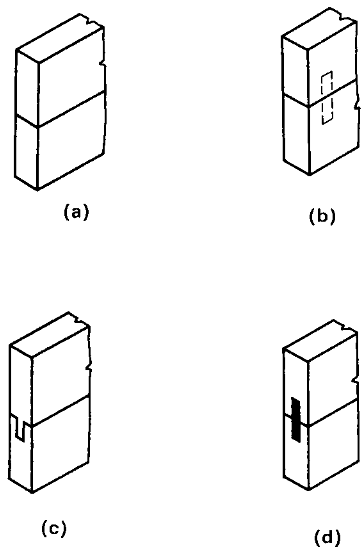


FIG. 10.30. Joining two boards. (a) Butt joint. (b) Dowel joint. (c) Tongue and groove. (d) Loose tongue.

dowels, tongues and grooves or grooves with separate slip. Joining of timber lengthways requires a scarf joint together with some form of fastening (Fig. 10.31).

The clamped joint used in making drawing boards, pastry boards, table and bench tops increases the length of the material and also prevents any warping.

Single joints are usually easy to make, but as the aim is to build up a frame or carcase which is strong and square, the most

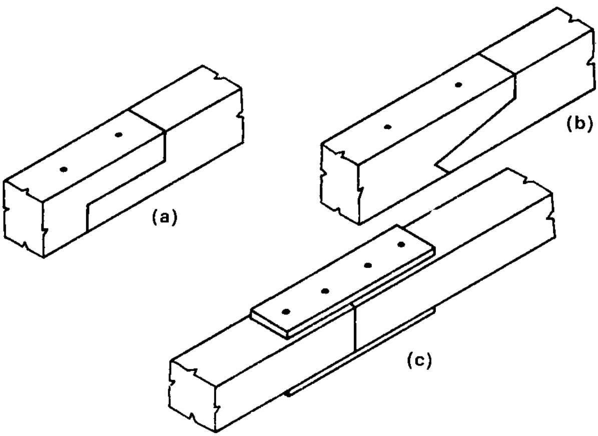


FIG. 10.31. Increasing the length of timber. (a), (b) Scarf joints. (c) Fish plate joint.

important part is the marking out. All like members should be marked together and all processes should be carried through separately, that is to say, when making a frame:

(1) Mark shoulder lines and lengths of all like pieces together.
(2) Gauge all the tenons.
(3) Gauge all the mortises.
(4) Saw all the tenon cheeks.
(5) Saw all the tenon shoulders.
(6) Chop out all the mortises.
(7) Assemble and glue the frame.

Following everything in an orderly fashion will avoid unnecessary work and above all unnecessary mistakes. Another golden rule, especially when measurements are involved, is to check and recheck. Check "handing", which is marking out and cutting opposing left and right hand pieces in correct position. Check always the positioning of mitre angles, dovetails and tenon haunches before cutting.

Chapter 11

Adhesives, Nails, Screws and Fittings

JOINTS are best secured with glue and as has already been pointed out, the greater the number of glued surfaces, the stronger the joint. Once animal glues were the only glues available, but now a very large range of adhesives are available and they fall into definite categories according to their manufacture. Some general rules can be given about the process of gluing, but often the specific directions of the manufacturer must be strictly followed.

First, the surfaces to be glued must be free from dust, grease, polish and old glue. The latter is especially important when carrying out repair work, for it is absolutely essential to remove all traces of old glue.

All surfaces which are to come in contact with each other should be glued, although there may be some modification of this statement when using some synthetic glues.

Some form of cramping or holding in position is necessary while the glue is setting, but it is not always necessary to cramp up too tightly. Some synthetic glues do not penetrate the wood and require a glue line even as much as 0·25 mm ($\frac{1}{100}$ in.)

Wash off all surplus glue before it hardens. If hardwoods are being used there is sometimes a tendency for glue to stain the timber or at least mark it, so that it is useful to give the wood surrounding the joint a coat of polish before gluing, but care must be taken not to polish the joint.

Hands should be thoroughly cleaned after gluing and when using some synthetic glues the use of a barrier cream is often advised.

Animal Glues

These are made from bones, hooves, etc., of animals and may be in the form of jelly, pearl, powder or cake and need adding to water and heating, but can be obtained ready for use. The glue is used hot and hence the assembly time is short, but the drying time long.

Casein Glues

These are made from milk and are obtainable in powder form, which is mixed with water, but once mixed the glue cannot be kept. They have good resistance to water, but are liable to stain and take up to 8 hours drying time.

Synthetic Resin Glues

These are mainly urea formaldehyde and may be in syrup or powder form. They require the use of a hardener and as setting is a chemical action, heat will accelerate the process. They have high resistance to water and heat. In some cases the glue is applied to one surface and the hardener to the other.

Phenol glues usually require heat controlled presses.

Epoxy Resin Glues

These are in the form of syrup and hardener and when set are extremely hard and resistant to water and heat. They can be used for jointing most materials including metal, glass and plastics.

PVA Glues

These are made from polyvinyl acetate and are in the form of a creamy liquid. The glue has unlimited shelf life, that is to say, it does not deteriorate on keeping. It has good adhesion on end grain and is an excellent general purpose glue. It was originally used for adding to cement for making thin screeds, and some brands will become transparent on re-activating with methylated spirits and can be used for joining glass.

Rubber-based Glues

These are of two types; latex rubber and impact glues. The latex rubber is in the form of a creamy liquid and is useful for joining paper, cloth and for veneering. Impact glues are mainly used for gluing plastic laminate sheets to wood. Both surfaces are coated with glue, which is allowed to harden, and then the two surfaces are brought together. As they cannot then be moved, some form of careful registering must be used. One method is to lay a sheet of brown paper between the two surfaces and to press them together as the paper is withdrawn. This glue is not suitable for normal jointing.

The choice of glue depends on the convenience of using, speed in drying, the need for being heatproof or waterproof, the strength of the bond and the cost.

Nails, Pins and Tacks

These are used for fixing a great many materials and most of them are fixed to wood. Obviously the softer the material the larger the head. Large clout nails are used for asbestos (this is soft when new), large tacks for upholstery, but small escutcheon pins for metal. These are illustrated in Fig. 11.1 and captioned with their uses. The woodworker, however, is mostly concerned with wire nails (or French nails), which are round in section, with a fairly large head. These are suitable for holding pieces together, especially rough exterior work. The oval brad or nail is more suited to work near to the end of a piece of wood so as to avoid splitting. The lost head sinks itself below the surface ready for filling. The panel pin is a lighter nail suitable for thinner materials, such as plywood and hardboard. Special copper plated conical headed nails are used for hardboard. When nailing hardboard, pins should be spaced about 12 mm ($\frac{1}{2}$ in.) in from the edge and at 100 mm (4 in.) intervals.

A general rule in nailing is for the nail to penetrate the lower portion about twice the thickness of the upper piece of wood. The nails should be correctly positioned or the wood will split (Fig.

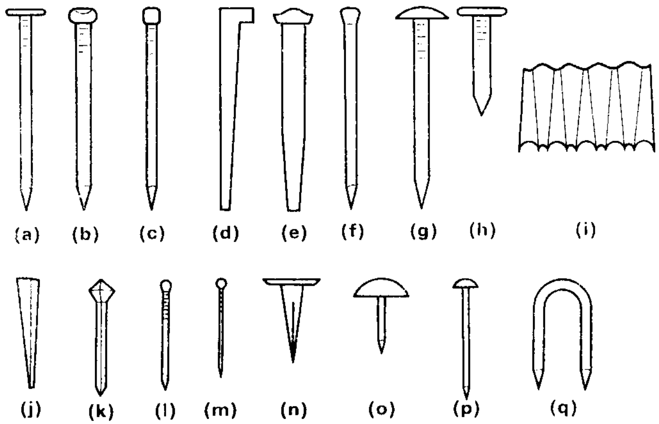


FIG. 11.1. Common nails and pins. (a) French or Wire. (b) Oval (c) Lost head. (d) Cut nail. (e) Floor brad. (f) Masonry. (g) Roofing nail. (h) Clout nail. (i) Corrugated fastener. (j) Glazing sprig. (k) Hardboard nail. (l) Panel pin. (m) Veneer pin. (n) Cut tack. (o) Upholstery nail. (p) Escutcheon pin. (q) Staple.

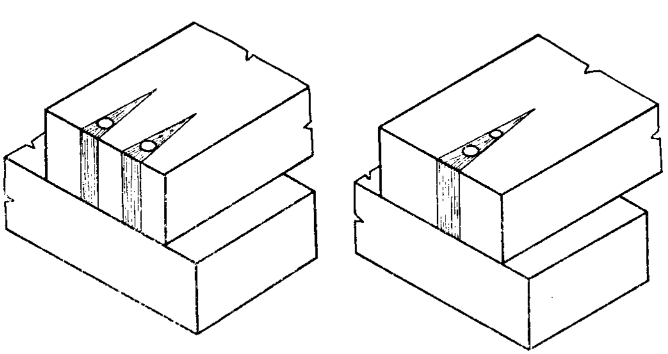


FIG. 11.2. Nails badly positioned tend to split wood.

11.2). When nailing near to the end of wood, it is best to make holes with a bradawl which is used at right angles to the grain. When using oval brads, put in the nails with the oval in the direction of the grain. Blunting the point of the nail will often prevent splitting. When several nails are in close proximity, staggering their position as in Fig. 11.3 will avoid splitting the wood. Nailing, too, is more effective if carried out in a dovetail fashion (Fig. 11.4).

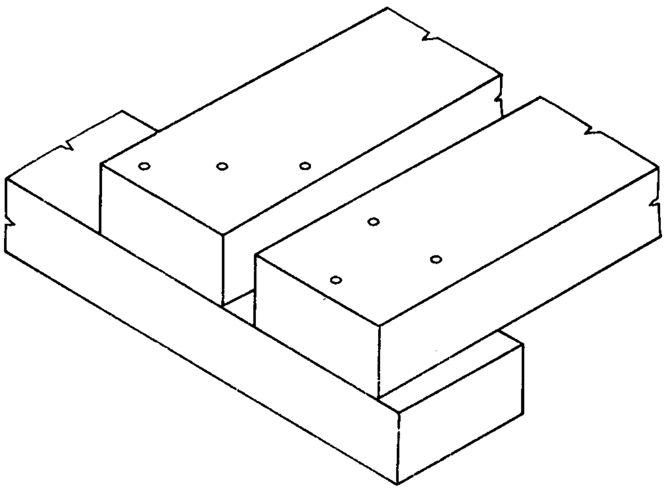


FIG. 11.3. Nails staggered.

Nails such as oval brads and panel pins can be punched down below the surface of the wood and filled with some form of stopping. Hardened steel masonry nails are suitable for fixing timber to walls.

Screws

These make a more secure form of fixing and have the advantage of being easily removed and replaced. It is not necessary to use glue when using screws, but often once a piece of wood has been prepared for screwing, it is an advantage to glue the piece in position and leave it to set before putting in the screws, thus preventing the piece twisting out of position.

Screws are classified according to the shape of their heads, i.e. countersunk, roundhead, raised head, and the various types are illustrated in Fig. 11.5. These screws have a shank and tapering screw thread, but there is a self-tapping screw, originally used for

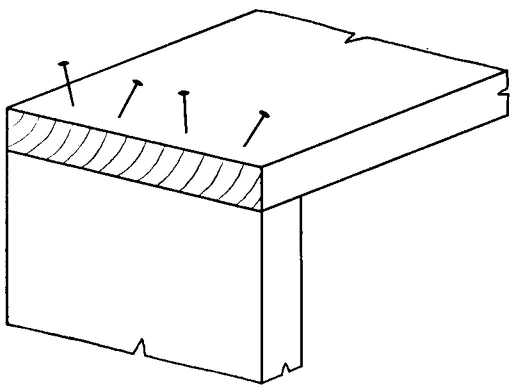


FIG. 11.4. Dovetail nailing.

metal fixing, but is now being used for wood. The self-tapping screw has the advantage of a parallel thread the whole length of the screw and is especially useful in working with chipboard. Until recent years screws have always been slotted and were driven in with the normal type of flat screwdriver blade, but are now often replaced by cross-head or Phillips screws. These are driven with a pointed cross-headed Phillips screwdriver. This type of screw allows for more positive driving and has less tendency for the driver to slip out of the screw slot.

Screws are also specified as to length and are obtainable in sizes from 6 mm (¼ in.) to 75 mm (3 in.) and also by gauge thickness ranging from 0 to 20. Obviously, not all gauges are available in all lengths. Notice that the smaller the gauge number the

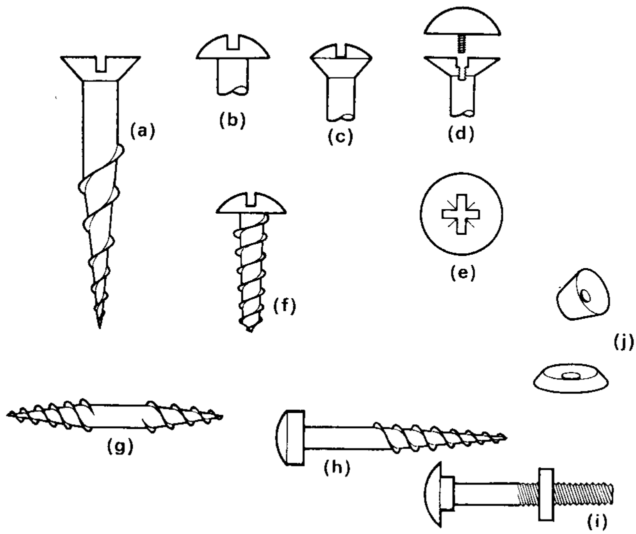


FIG. 11.5. Types of screws. (a) Countersunk. (b) Round head. (c) Raised head. (d) Domed. (e) Cross-head. (f) Self-tapping. (g) Double ended. (h) Coach screw. (i) Coach bolt. (j) Countersunk and surface cups.

thinner the screw. A screw holds two parts together and the shank of the screw should be no longer than the thickness of the top piece. Because of this a clearance hole is drilled into the top piece the size of the shank, and to facilitate screwing, a hole is drilled in the lower part equal to the core diameter. For countersunk and raised head screws the clearance hole is countersunk to receive the screw head. The various stages in boring holes for screwing are shown in Fig. 11.6. A recent innovation is the screw

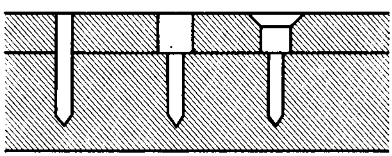


FIG. 11.6 Stages in boring preparatory to screwing.

drill which combines a drill and countersink to give core diameter and clearance holes and countersink in one operation. It is made in various sizes and is most useful for quantity screwing and repetition work. Unfortunately, drills and screw sizes do not exactly match up, but Table 11.1 below gives approximate sizes for the common size screws.

TABLE 11.1. DRILL SIZES FOR WOOD SCREWS

Gauge of screw	Clearance hole		Thread hole	
	mm	inches	mm	inches
2	2·5	$\frac{3}{32}$	1·5	$\frac{1}{16}$
4	3·0	$\frac{7}{64}$	2·0	$\frac{5}{64}$
5	3·0	$\frac{1}{8}$	2·0	$\frac{5}{64}$
6	3·5	$\frac{9}{64}$	2·0	$\frac{5}{64}$
7	4·0	$\frac{5}{32}$	2·5	$\frac{3}{32}$
8	4·5	$\frac{11}{64}$	2·5	$\frac{3}{32}$
10	5·0	$\frac{13}{64}$	3·0	$\frac{1}{8}$
12	6·0	$\frac{15}{64}$	3·0	$\frac{1}{8}$
14	6·5	$\frac{1}{4}$	4·0	$\frac{5}{32}$

Screws are made of steel, brass, aluminium and other metals. Steel screws, which are the strongest, have the disadvantage of corroding, but a smear of grease or wax will aid both screwing and prevention of internal corrosion. Brass screws do tend to fracture, especially in hardwoods, so it is a good practice to insert a steel screw of the same size first and then to replace with a brass screw. Because of the rising cost of brass, brassed steel screws are beginning to replace those made wholly of brass, but the disadvantage of all plated fittings is that once the plating has been scratched then corrosion can set in. Screws are often galvanized, oxidized, black enamelled, or chromium plated and stainless steel screws are available for use with stainless steel fittings. For certain types of fittings, such as frameless mirrors, there are available domed screws which have screwed decorative heads or push-on plastic heads.

Engineers nuts and bolts have their uses for fixing wood and metal parts, but normally for holding wooden parts firmly together coach bolts are used. These have plain shanks with a wood screw thread and under the head is a square boss which is driven into the wood to prevent twisting when tightening the bolt.

Special dowel screws and double-ended screws are available for fixing legs and handles.

Two specialized methods of screwing are sometimes adopted. When fixing a table top to a leg frame, holes are drilled through the top of the rails at an angle so that they emerge from the side. Here a pocket or countersink is made with a gouge so that the head of the screw will sink below the surface of the wood (Fig. 11.7a).

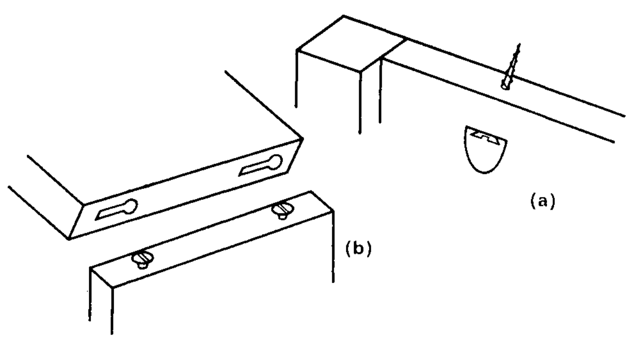


FIG. 11.7. (a) Pocket screwing. (b) Secret slot screwing.

Secret slot screwing joins two pieces of wood together so that they are easily parted and assembled (Fig. 11.7b). Position for the holes are off-set by about ½ in. and a hole the size of the screw head is drilled in the lower portion. Slots are made equal to the shank diameter and then the screwed part is dropped onto the lower part and hammered so that the heads of the screws cut their own shaped slots.

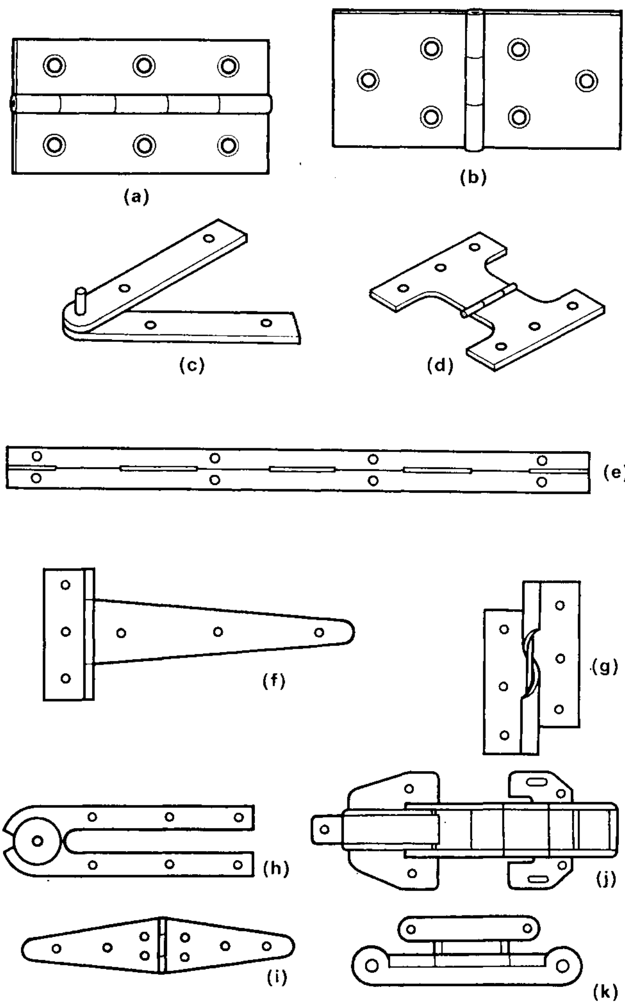


FIG. 11.8. Types of hinges. (a) Butt. (b) Back-flap. (c) Centre pin. (d) Parliament. (e) Piano. (f) Cross garnet. (g) Rising butt. (h) Trestle. (i) Strap. (j) Lay-on hinge. (k) Semi-concealed.

Fittings

A list of these for woodwork literally runs into hundreds, but a rough classification divides them into hinges, catches, locks, handles, stays, shelf fittings, brackets. It is well for the technician to familiarize himself with a catalogue of fittings, as they can often be used to improvise apparatus. For instance, the mechanism for swivel-type chairs is not expensive and could be incorporated in a demonstration model.

Most fittings are easy to fit, but hinges and locks do require some systematic and orderly preparation.

There are a number of types of hinges and some are illustrated in Fig. 11.8. The most common of these is the butt hinge, but where greater support is required, back flaps are used. For cupboards which have adjacent doors on the front of the carcase without spaces between them, special lay-on hinges are available which allow the doors to open within the width of the cabinet. Piano hinges, made in both metal and plastic, are easy to fit because there is no need to recess the hinge. Plastic, especially nylon, is becoming increasingly popular for the manufacture of catches and hinges, because they produce a tough product that is quiet in use and never needs lubricating.

The butt hinge is wholly recessed into a door if it is within the carcase, but if it fits outside, as in the lid of a box, then a leaf is recessed into each part.

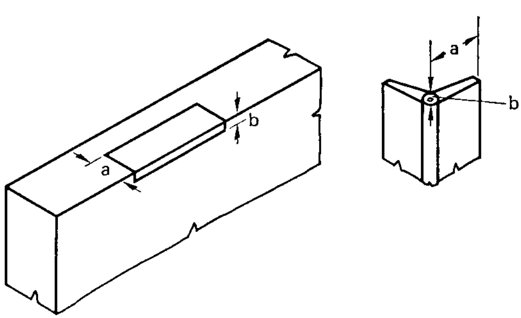


FIG. 11.9. Setting out hinge with a gauge.

To fit a hinge (Fig. 11.9), mark out the position and square lines across with a knife. Gauge the width of the hinge setting the gauge to the centre of the pin, and gauge the depth setting to the thickness. The recess is chopped out with a chisel in short cuts the full width of the recess and is cleaned out by carefully paring across. Having screwed in the hinges on to one part only, fix the door or lid to the main carcase by one screw in each hinge, then any adjustment can be made by using the other screw holes.

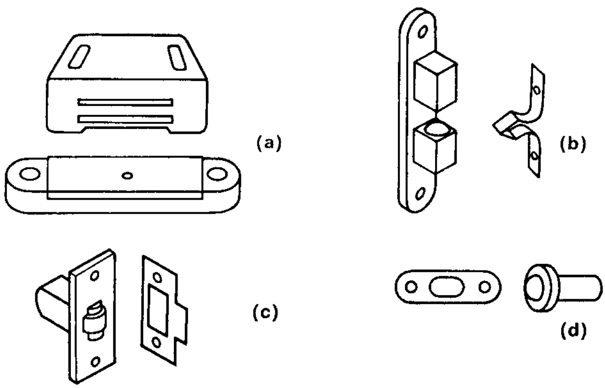


FIG. 11.10. Types of catches. (a) Magnetic. (b) Spring. (c) Roller. (d) Ball catch.

Doors and drawers are kept closed with either catches or locks (Fig. 11.10). Catches (except ball catches) and some locks are surface fitted. Having fitted one piece, the striking plate can often

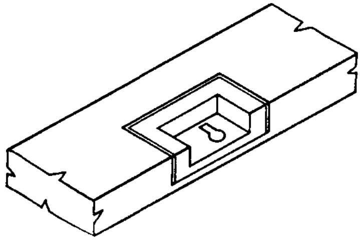


FIG. 11.11. Recess for drawer lock.

be located by means of small locating pins found on the back of the plate, otherwise the inside of the cupboard should be chalked or carbon paper interposed to mark the position.

Figure 11.11 outlines the procedure for recessing locks into doors or drawers. The important operation is to correctly gauge the centre of the lock pin and mark its position on to the wood, bore the hole, use a keyhole saw to form the keyhole and then the parts to be recessed can be marked from the lock itself.

Chapter 12

Finishing of Woodwork

COMPLETED constructions need cleaning up ready to apply some finishing and protective surface. Any surface glue that remains after removing cramps should be chipped off with a chisel, and then the surface can be planed with a smoothing plane. There are three points to note:

(1) Watch the direction of the grain to avoid unnecessary tearing of the timber.
(2) When planing frames, allow the plane to swing into the direction of the cross-member.
(3) When planing carcases where end grain is visible, always plane from each end towards the middle of the work.

Surface grain that is liable to tear can be planed across the grain with a very finely set smoothing plane, or very badly torn patches can be smoothed with a scraper.

The scraper plane works effectively, but the flexible cabinet maker's scraper does allow smaller areas to be smoothed. The direction of the grain of the tear can always be felt with the fingers.

Work can now be finished with some form of abrasive. These are divided into glasspaper, garnet paper, emery paper, silicon carbide papers, aluminium oxide paper and steel wool of various grades, and there are other finer abrasives, such as pumice and iron oxide.

The woodworker is concerned mainly with glasspapers and garnet papers, which are obtainable in grades 3, S_2, M_2, F_2, $1\frac{1}{2}$, 1, 0, 00 and flour, or in continental grading 0 to 9/0, but for normal work grades M_2 to 0 are the most suitable.

Garnet paper is a more durable abrasive, which can be used by hand, but has a greater use on both disc and belt machine sanders. Glasspaper should be cut in half and used round a glasspaper block made of cork, or wood covered with cork lino, and should be about 100 mm × 75 mm (4 in. × 3 in.). Use the glasspaper so that the rolled surface is at right angles to the grain. If the open end is used, the edge of the paper can catch in a loose fibre and tear out a large piece of wood. This is particularly important when papering veneer. It is most important that all glasspapering is done in the direction of the grain, because papering across the grain produces cuts in the fibres which are accentuated when stained, polished or painted. Never allow the block to run off the edge of the wood for this will tend to round the edges. Hold the work firmly and use both hands on the block to get maximum pressure. Particular attention should be paid to end grain, which can always be brought to a high polished finish by just papering.

The machine sander will obviously do this rather laborious work very much quicker, but experience is necessary to produce a really flat finish, as uneven pressure or erratic movement will cause digging in or surface undulation. The disc attachments to power drills remove a good deal of wood, but tend to give too many cross scratches. Orbital sanders give a very good finish but remove very little wood. The belt sander is the most effective, but, of course, is a large and expensive machine for occasional work. Garnet and silicon carbide or aluminium oxide papers or cloths are used with machines and these may be open coat for use on soft materials or closed coat for harder materials. These are graded either as 0/1, 0/2, etc., or by grit sizes from 600 which is very fine, down to 16 which is very coarse.

Stopping

Stopping is the process whereby large defects and cavities in wood are filled with some type of pliable material which will finally set hard. There are many proprietary stoppings which are made in shades to match the various timbers. Plastic wood is a stopping which dries very quickly. Stoppings are applied with a filling knife and when hard are sanded level. Polyurethane stoppings form hard ready-to-paint surfaces for painted work.

Filling

To obtain good surface finishing, the grain of the wood should be filled. The filling used depends on the finish, because the use of various solvents demands use of particular fillers and this is very true of cellulose and some polyurethane polishes. For french polish finishes, a paste of plaster of paris can be used and the whiteness is "killed" with linseed oil. Today proprietary oil fillers in matching colours are used. These are applied with a cloth and rubbed with a rough material, such as hessian, across the grain to remove surplus filler and yet leave the grain filled. When set it is sanded down.

For paint work cellulose plastic fillers are used and these are best applied after the priming coat, because then the filler is trapped between two waterproof coats.

Staining

The colouring of wood is done before polishing. There are four types of stain; water stain, spirit stain, oil stain and chemical stain.

When using water or chemical stains, the grain must be "raised", that is, the wood is wetted with water and allowed to dry and as this makes the wood rough it is then sanded down. After repeating this process the wood will no longer become rough when wetted with water stains. Water stains are available in various shades of yellow, brown and red and are applied with a brush, and as with all water based paints or stains, the edges should be kept wet, as the work proceeds, in order to avoid patchiness.

The chemical stains that produce various shades of brown on oak and mahogany are solutions of potassium dichromate, potassium permanganate and ammonia (fumed oak). When using these, the grain requires raising.

Spirit stains which are obtainable in many colours are all dissolved in methylated spirit. Staining must proceed rapidly in order to keep the edges wet and so produce an even colour.

Oil stains which are obtainable in various shades are nearly fool-proof in application, whether by cloth or brush, for they never appear patchy. These are the stains to be recommended.

It is best to preserve the natural colour of the wood, but if stains are to be used, make sure the surface of the wood is well finished for stains accentuate any blemishes.

Polishing

A surface polish can be obtained by using wax, button polish, cellulose or polyurethane. Wax polish is applied with a cloth, but for quick results the timber should first be sealed with a coat of button or white polish. Any good floor or car wax polish is suitable.

French polishing is done by using a "rubber" made of a layer of cloth with an interior pad of unbleached wadding and, although cotton wool can be used, it does tend to become lumpy. The pad, acting as a reservoir, is filled with polish which may be white polish, button polish or garnet polish. The process is carried out by going over the surface, and releasing the polish by pressure through the cloth. The action is like writing a series of cursive E's over the surface. Because the solvent dries quickly, the process can be repeated immediately, but often a smear of linseed oil on the surface of the "rubber" is necessary to prevent it sticking. The french polishing process is a skilled art and only experience can produce the results of the expert.

Modern finishes which are heat-proof, water-proof and often alkali-proof are obtained by using cellulose, polyurethane or melamine. Cellulose is best sprayed on, but brushing grades are obtainable. The final surface is rubbed down with a fine grade of silicon carbide paper and then burnished with polishing paste. Polyurethane and melamine are obtainable in two part packs which are mixed in exact proportions and harden by chemical action, but final hardening takes as long as seven days. The final finish is obtained by sanding and burnishing with polishing paste. Polyurethane is also obtainable in a single pack, but although it is not as durable as the two part polish, it is easily applied, more economical and would be suitable for most laboratory work.

Painting

A good surface finish to the wood is essential for a good paint finish. Modern paints are easy to apply with brush or spray, and coats of primer or sealer undercoat and top coat should be given. All coats should be sanded before applying another, but finishing gloss paints can be applied coat on coat.

Polyurethane paints are more expensive, but far more durable, and will withstand knocks, heat, acids and alkalis. They are obtainable in two part packs or single packs and as thixotropic (non-drip).

Emulsions and acrylic paints are tough and durable, easy to apply, quick drying and have many useful applications, other than on walls and ceilings.

Chapter 13

Constructions

THIS chapter contains a number of projects useful both in the workshop and the laboratory. In some cases dimensions have been given, but generally a presentation of ideas is intended, which will serve as a guide rather than a series of working drawings.

Bench Hook

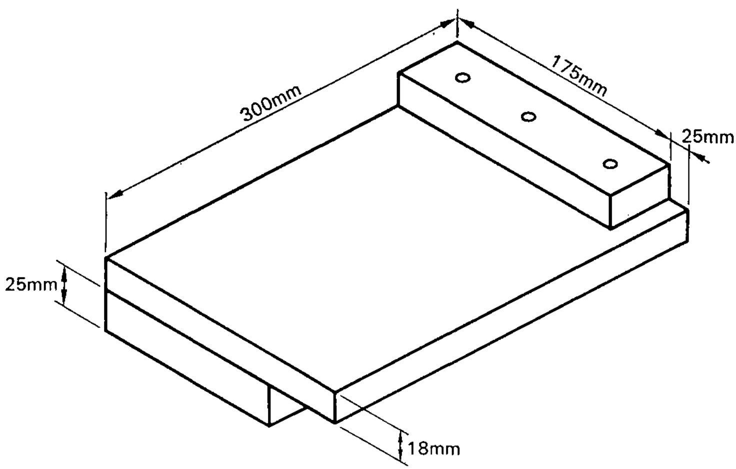


FIG. 13.1.

This is best made from beech, but any hardwood will be suitable.

1. Cut to size and square accurately the pieces required.
2. Glue the two blocks in position and allow to set.
3. Bore holes and glue in lengths of dowel rod. When dry, clean off with a plane.

Shooting Board

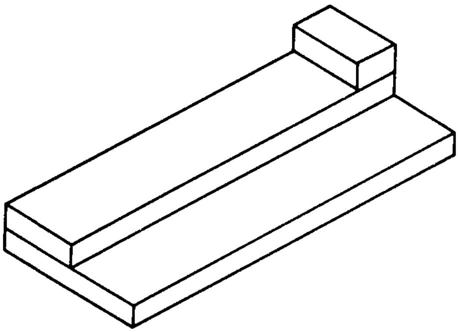


FIG. 13.2.

This is made from beech or other hardwood or good quality softwood.

1. Prepare all pieces to size and with all edges squared accurately.
2. Drill and countersink holes for screws.
3. Glue and screw the small block to the top guide board. Carefully position the block so that it is square with the board.
4. Screw the guide board to the base board.

Mitre Block

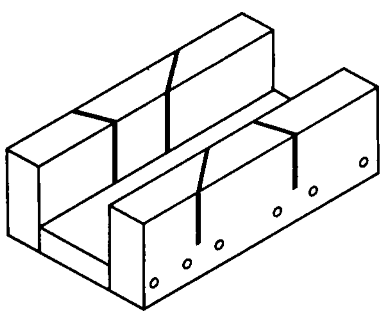


FIG. 13.3.

This is made from beech or other hardwood.

1. Prepare and properly square pieces to size.

2. Glue side pieces to centre piece and allow to set.
3. Mark out for mitre cuts.
4. Bore holes and glue in lengths of dowel so that each section is held by two dowels.
5. Make mitre cuts.

Balance Bridge

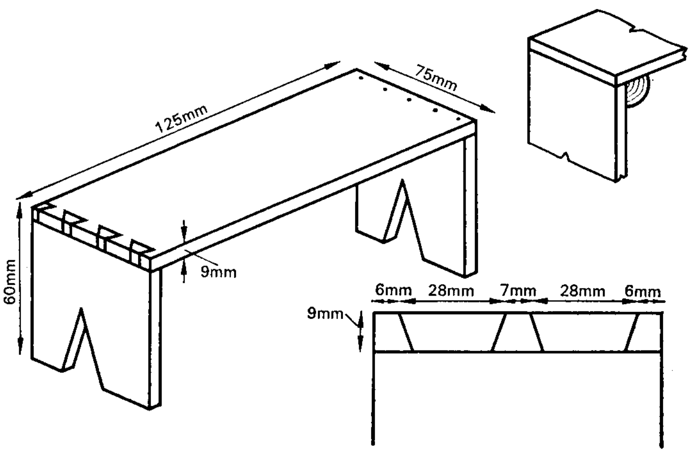


FIG. 13.4.

This is made from good quality timber.

1. Cut pieces to size and square ends.
2. Shape end pieces.
3. Glue and pin pieces together.
4. Glue in corner blocks

— or —

5. Mark out and cut dovetails.
6. Glue together.
7. Clean off and smooth with plane and glasspaper.
8. Give one or two coats of suitable polish.

Lens Holder

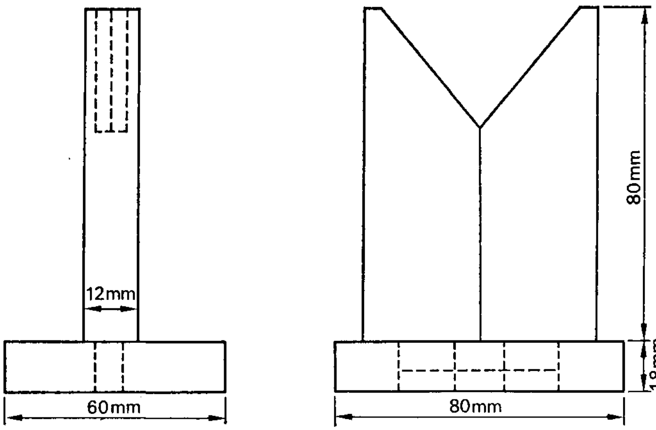


FIG. 13.5.

This is made from mahogany or other hardwood.

1. Prepare pieces for the base and holder. The holder is made from two pieces with one end of each mitred at 45°.
2. Cut Vee-slots in each mitred end, marking out with a gauge and making saw cuts. The Vees can be smoothed with a shoulder plane or a shaped glasspaper block.
3. Glue the two halves together.
4. Mark out and cut tenons.
5. Clean up with glasspaper.
6. Glue two parts together.
7. Polish.

Storage Stand for Burettes

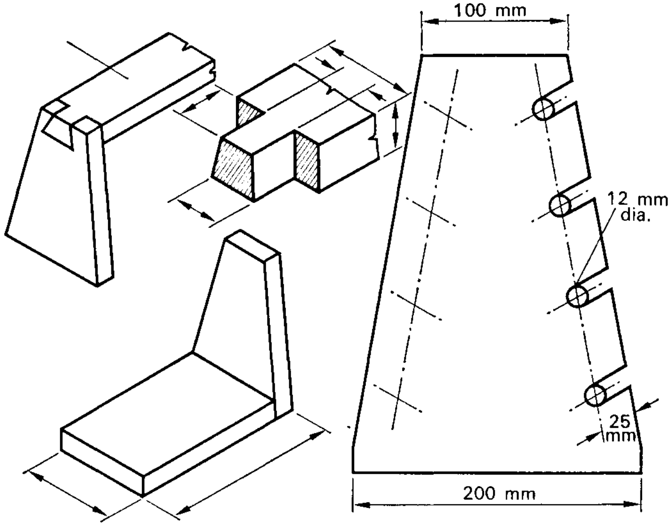


FIG. 13.6.

The base and handle are made from hard or softwood. The sides are made from 9 mm plywood or 18 mm hardwood.

1. Prepare pieces to size and shape.
2. Mark out for slots.
3. Bore holes and make saw cuts to form slots. The pieces can be glued and nailed together if not to be used as a carrier.
4. Mark out dovetails for handle and base.
5. Cut dovetails.
6. Assemble with glue.
7. Clean up with plane and glasspaper.
8. Give protective coat of polish.

Manometer Stand

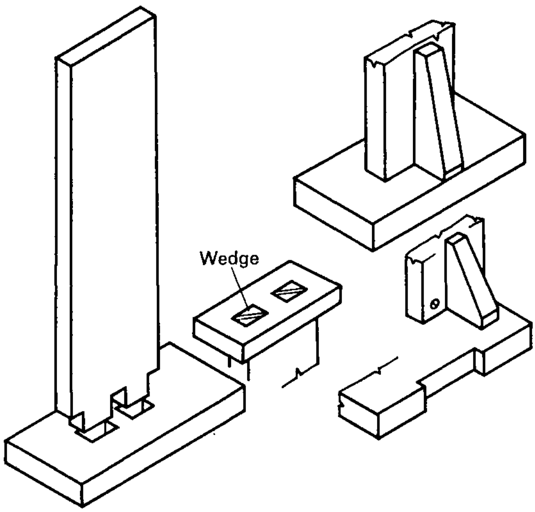


FIG. 13.7.

This is made from mahogany or other hardwood.

1. Prepare pieces to size.
2. Mark out and cut mortise and tenon joint. Wedges should be used fitted diagonally across each tenon.
3. Clean up with plane and glasspaper and glue together.
4. Polish

— or —

Make shaped rear supporting blocks and glue and screw these to the base or to a housing in the base.

Inclined Plane

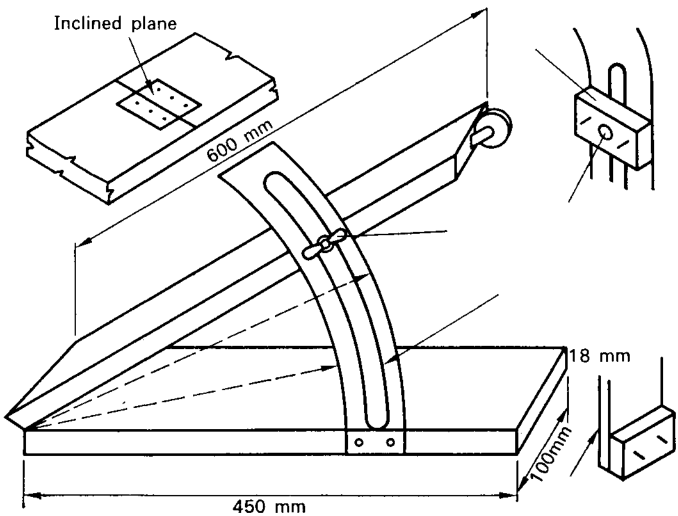


FIG. 13.8.

This is made from beech or mahogany.

1. Prepare the two boards to size.
2. Fit hinges and pulley.
3. Make the quadrant from plywood or metal. The slot is cut by drilling a series of adjacent holes and finish shaping with a file.
4. Fit a small coach bolt and wing nut to a plywood plate, which is then screwed to the edge of the inclined board.
5. Screw the quadrant to the base board with a distance piece inserted.
6. Glasspaper and polish to a very fine surface.

Cupboard Storage

Narrow shelves are glued and nailed to a bearer screwed to a side of the cupboard.

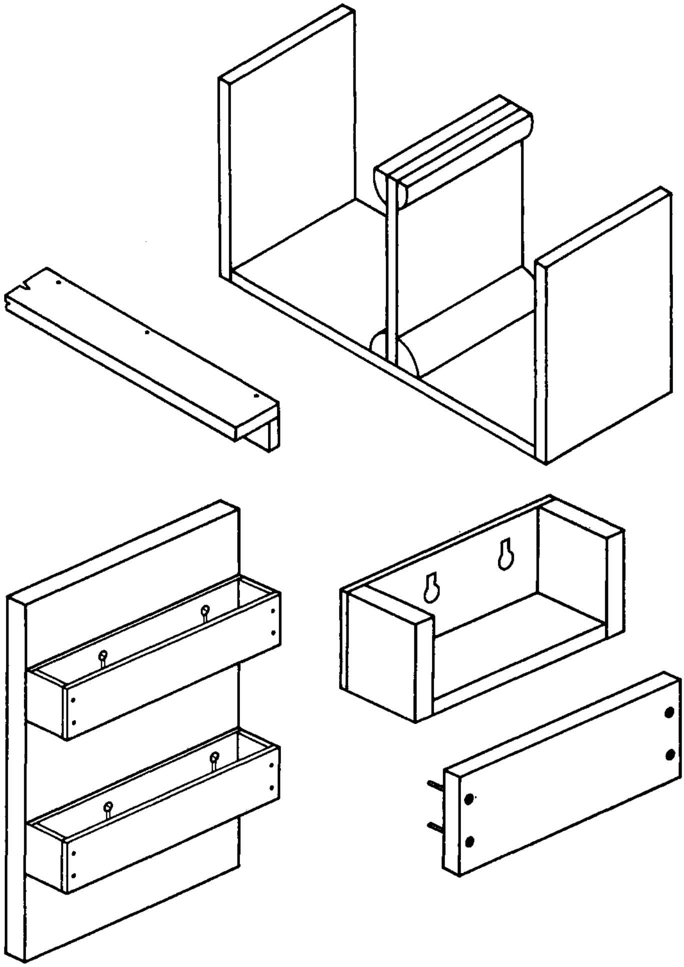


Fig. 13.9.

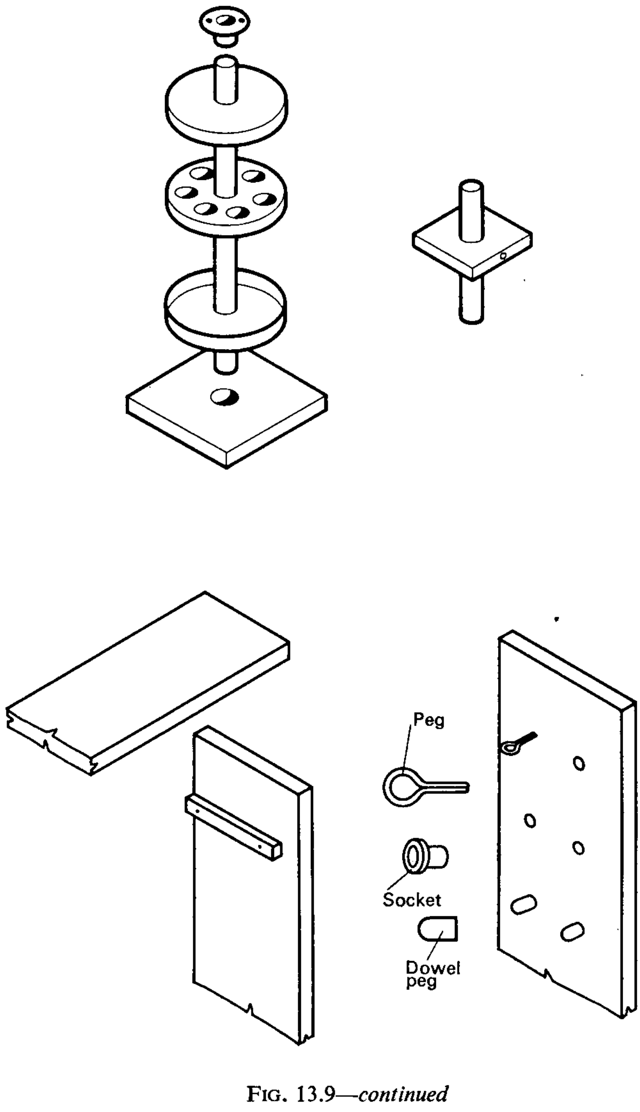


FIG. 13.9—*continued*

Additional shelves in cupboards can rest on bearers; on dowel pegs fitted in holes bored at intervals, or on brass shelf pegs and sockets.

Extra dividers can be fitted in lengths of plastic grooved track, or fixed by pieces of quadrant beading glued to the shelves.

Small boxes constructed from plywood and softwood can be screwed to the inside of doors, or hung by means of keyhole slots.

A turntable can be fitted between a hole bored in the floor of the cupboard and a metal socket above. Circular shelves can be plain, bored with holes or rimmed with plywood or metal. The shelves are fixed to blocks, which are screwed or dowelled to the central pillar.

Door Construction

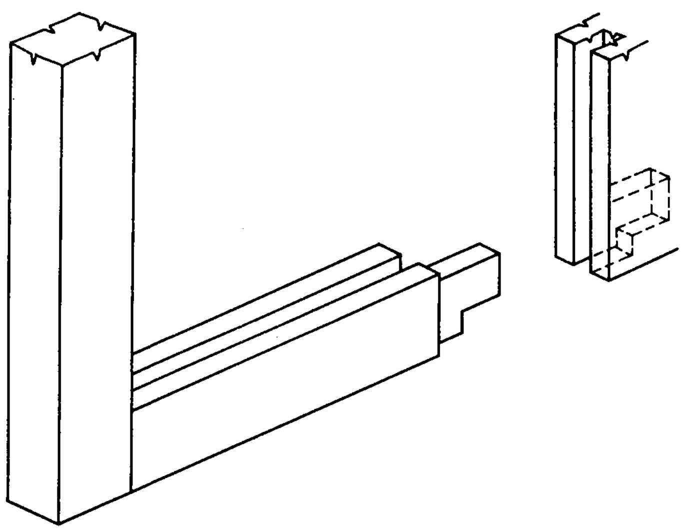


FIG. 13.10.

The simplest door is made from a piece of blockboard and it is often lipped, especially on the hinged side, to avoid using end grain.

Framed doors can be made with butt joints glued and secured with corrugated fasteners, dowelled joints or mortise and tenon

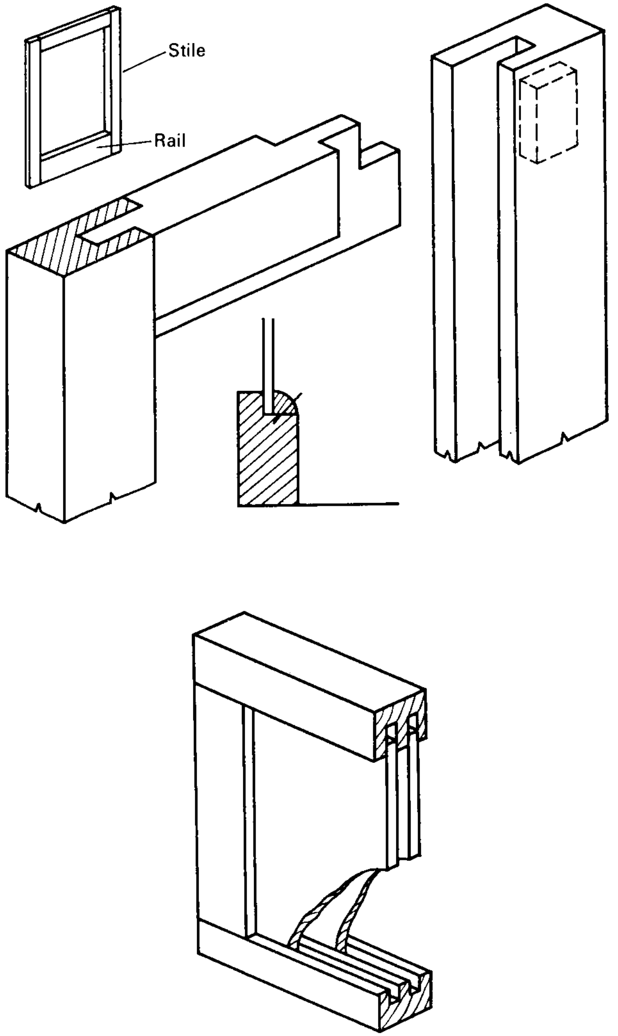


FIG. 13.10—*continued.*

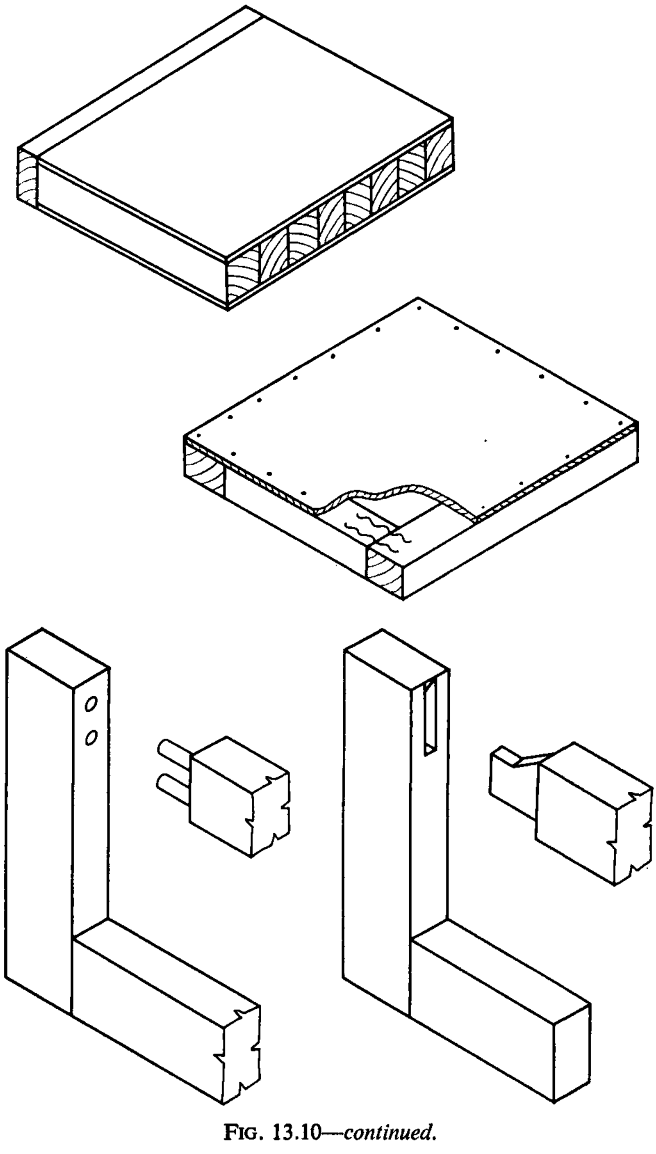


FIG. 13.10—*continued.*

joints. The frames can be clad with panels of hardboard or plywood glued and pinned either on one or both sides.

Older type framed doors are made with mortise and tenon joints with long and short shoulders and the rails and stiles rebated to receive a panel, which is held in position with a small beading.

In other doors, the members are grooved and panels are fitted at the same time as the frame is glued.

Simple sliding doors can be made from hardboard stiffened by strips which act as door pulls. These doors slide in grooved track, the grooves of the top track being double the depth of the grooves of the lower track, to enable the doors to be removed.

Drawers

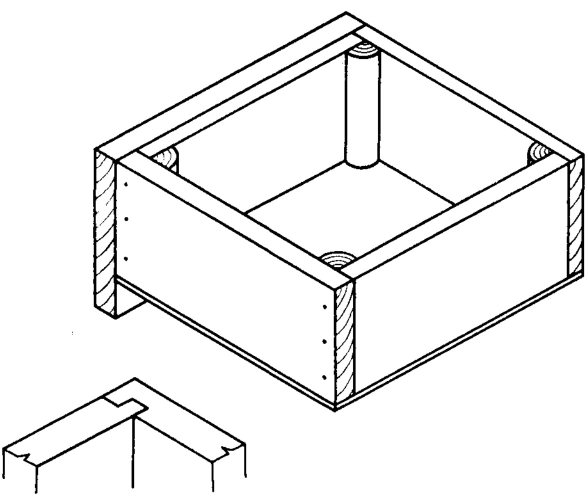


FIG. 13.11.

A simple drawer can be made by gluing and nailing four pieces (they must be square at the ends) together and strengthening the corners with glued blocks. A plywood bottom is glued and pinned on. An extended false front is glued on and this strengthens the construction and hides the end grain and drawer runners. A

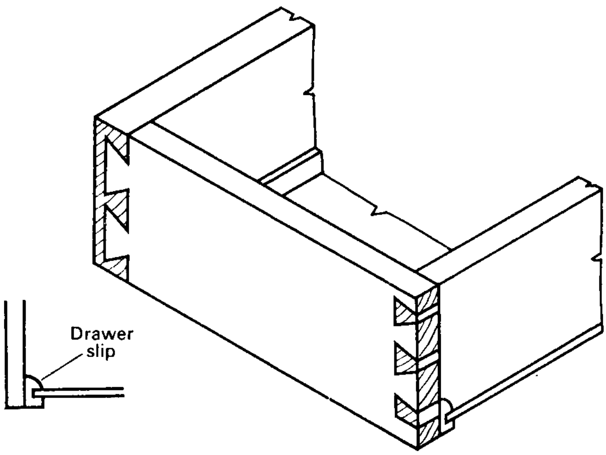


FIG. 13.11—*continued.*

tongued and grooved joint would be stronger and needs no corner blocks. The conventional construction uses dovetails on all corners, but notice the setting out of the back dovetails. The bottom panel slides in drawer slips, which are glued and pinned in after the drawer is glued up. A groove is ploughed in the front of the drawer to support the panel. The back is made shallower than the sides, so that the bottom can be fitted after the drawer has been assembled. Two panel pins driven through the plywood into the back prevent it moving.

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