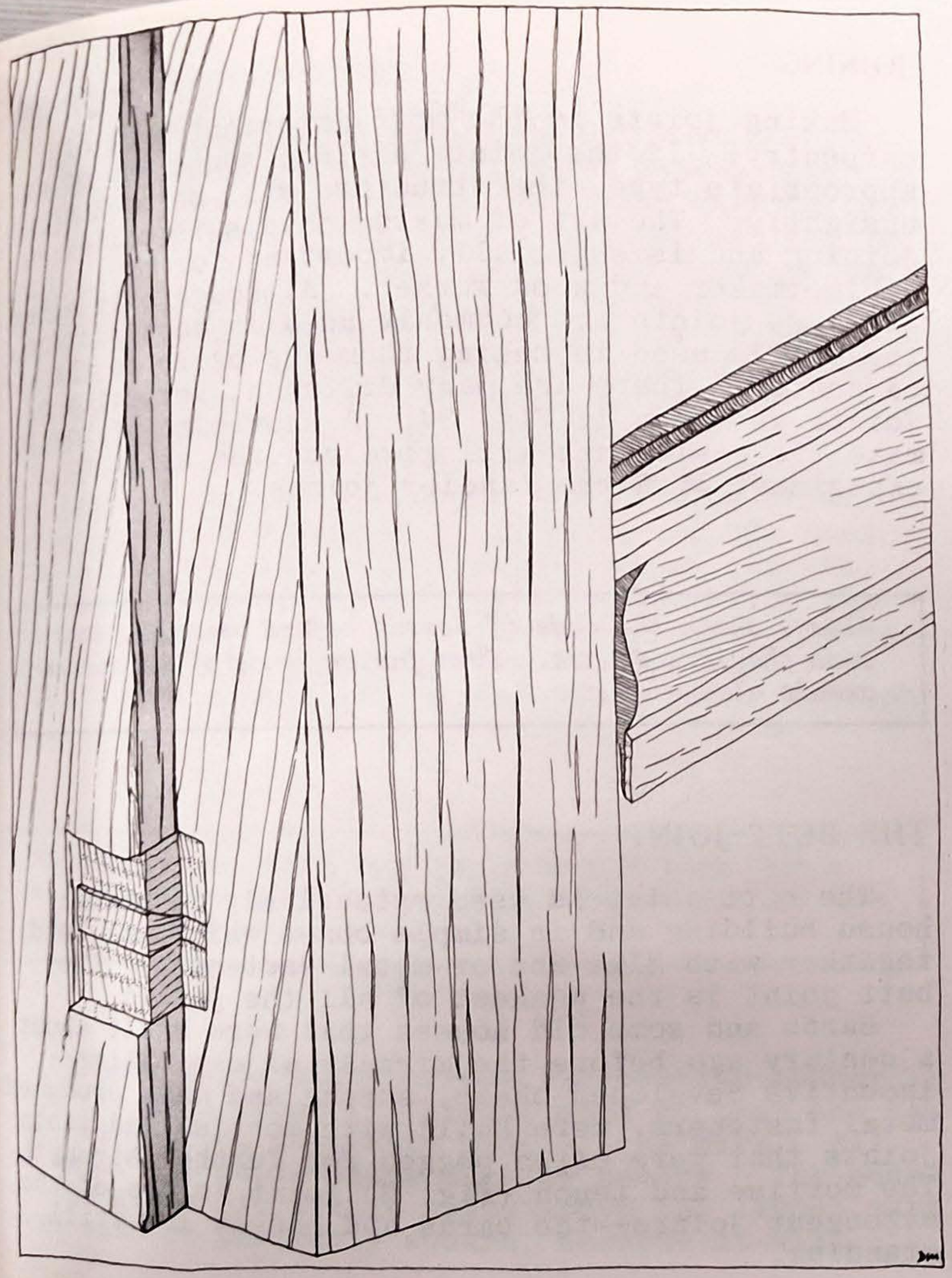


Chapter 4

Joining

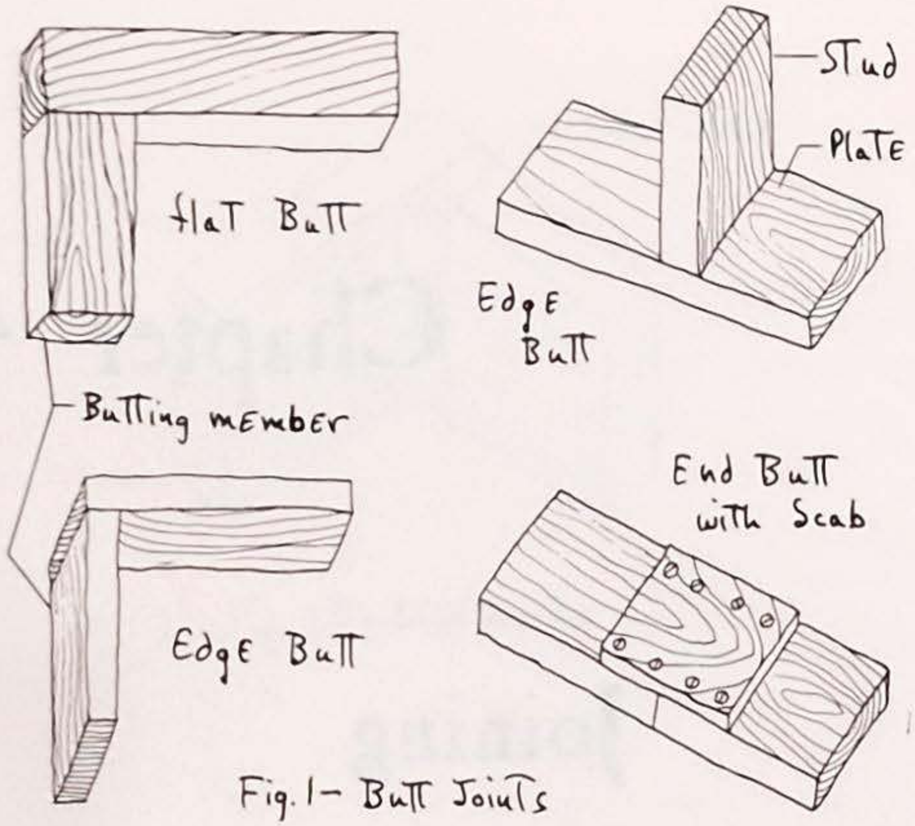


Fig. 1- Butt Joints

JOINING

Making joints is the most important part of carpentry. If the joints are not sound and of an appropriate type, the structure will be weak or unsightly. The art of making joints is called joining and is especially important for the cabinetmaker and wood worker. Although only a few of these joints are commonly used in construction, the skills used in making them are basic to the carpenter. There are many different varieties of joints as shown in Fig. 34. A knowledge of how to make the basic ones will give you the skill to experiment with the fancier joints.

Always check the ends of boards before using, to make sure they are square. Even factory ends of new lumber aren't always square.

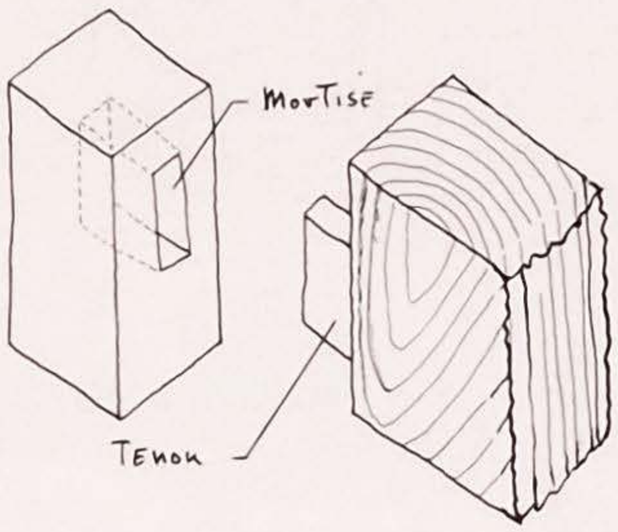


Fig. 2- Mortise & Tenon Joint

Mortise and tenon

THE BUTT JOINT

The butt joint is used extensively in modern house building and in simple boxes which are held together with glue and/or metal fasteners. The butt joint is the weakest of all the joints.

Barns and some old houses that were built about a century ago before the miracle of capitalist incentive developed cheap, strong and mass produced metal fasteners, were built with mortise and tenon joints that were often pegged for further strength. The mortise and tenon (Fig. 2) joint is one of the strongest joints--the barns and houses are still standing.

Making A Perfectly Square Cut

The important thing in making a good butt joint is making a perfectly square, clean cut on the edge of the butting member. The word "square" in carpentry denotes a 90° angle (also called a right angle). In construction, "square" is used to describe the corners of a house or foundation. The walls must come together at 90° angles at the corners or there will be trouble later making the interior and exterior trim fit. In joining, a square cut means that the cut across the face of a board must form a right angle with the edges of the lumber. Fig. 1. This is not as easy as it would seem. It requires a perfectly square tool like a framing square or T-square which has not been banged around but has been treated like the precision tool it is. With this perfectly square square, lay out the cut on the butting member, using a fine pencil (#3 or #4), a knife or scratch awl.

When doing fine, exact work it is best to work from a scratch mark or knife cut which is much thinner and more precise than a pencil mark.

Clamp a guide block across the butting member with its edge along the layout mark so that the saw kerf will be on the waste side of the mark. All edges of the guide block must be square. The edge of the guide block that rises above the layout mark must also be perfectly square, because it will

Square

Scratch awl

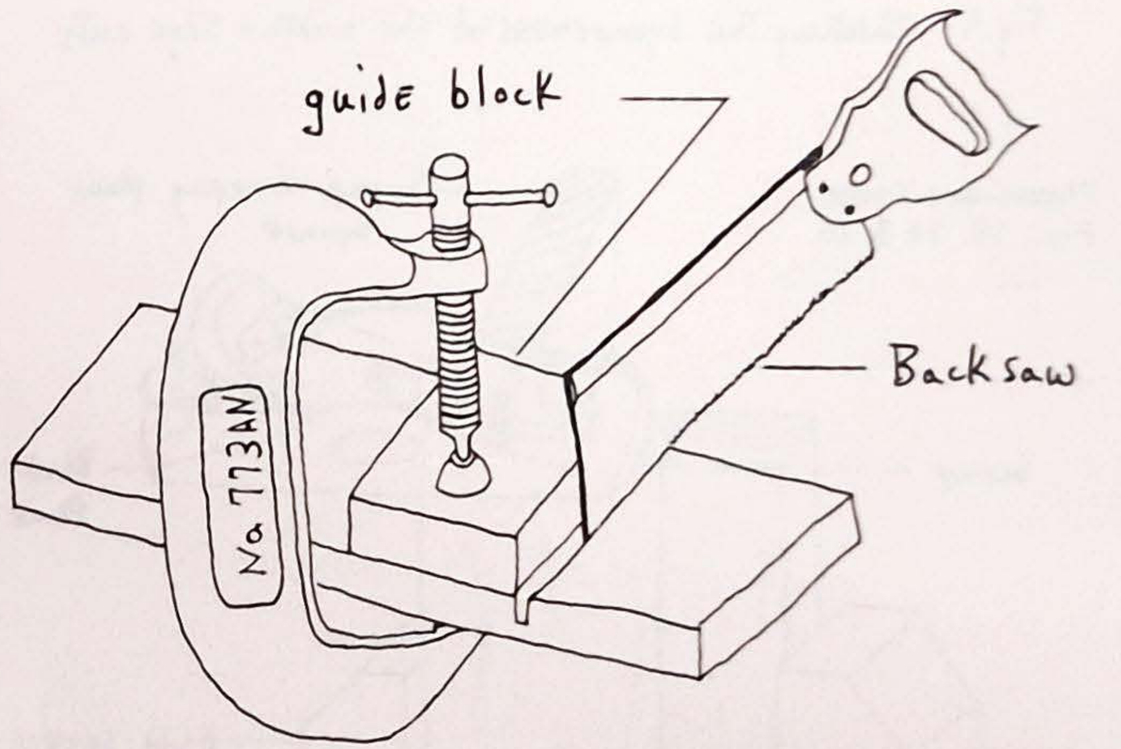


Fig. 3 - Making a Square Cut

Waste side of line--
See Tools: Fig. 8

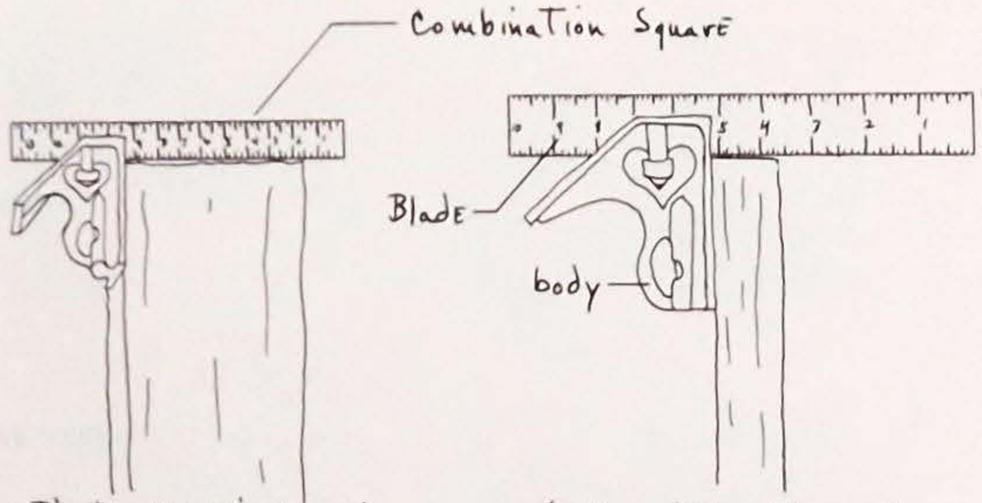


Fig.4 – Checking The Squareness of The width & Edge cuts

Planes–See Tools:
Figs. 13. 14 & 15

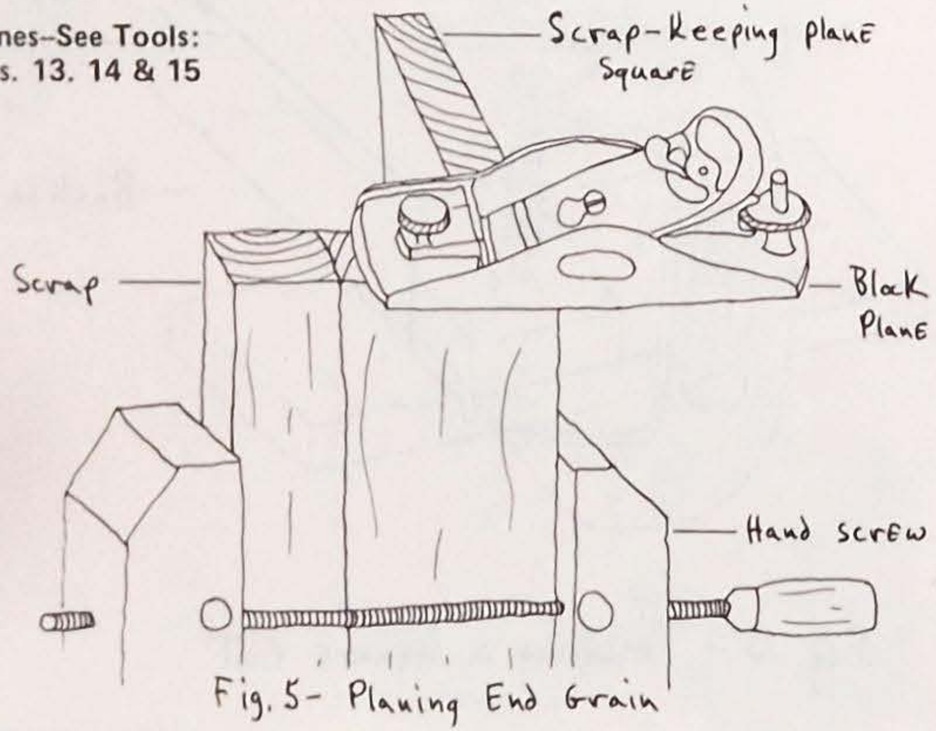


Fig. 5- Planing End Grain

Planing end grain

guide the saw blade as it cuts down into the butting member, ensuring that the edge cut is also square. To form a perfect butt joint, the cut along the width dimension and the thickness dimension must be square.

Making The Cut

When the guide block is securely clamped in place, the cut can be made. Hold the width dimension of the back saw flat against the guide block with your fingers or a small block of wood, while you carefully make the cut. Use long steady strokes, or sawdust cut in the middle of the board will not be dragged out of the end of the kerf by the teeth of the saw (one purpose of saw teeth). The sawdust will build up in the kerf and bind the blade if you take short strokes.

Fitting The Joint

When the cut is completed, hold the butting member against the other piece of wood. If all parts of the cut edge contact the other piece of wood evenly, then the intersections of the edges and sides of both pieces will be smooth and the butting member can be nailed, screwed and/or glued to the other piece. However, if the cut is sloppy and all surfaces are not even, the butting member will have to be planed along its thickness dimension to make the joint fit well. Planing end grain is difficult because the plane iron must be very sharp and because there is a tendency for the wood to split out at the edge as the plane goes over. To prevent this, clamp a piece of scrap wood along the edge to support the wood fibers. Fig. 5.

Another piece of scrap can be clamped so that its end (which must be square and straight) and face are perpendicular with the face sides of the piece to be planed--forming an "L". The plane bottom rides both on this second piece of scrap and the piece to be planed so it planes a square edge. A block plane is the best plane to use for end planing because its blade (plane iron) forms a smaller angle with the surface of the wood than the larger planes like the jack or smooth plane.

Back Saw

For this kind of finish work it is best to use a back saw which is also the kind of saw used with miter boxes. It is called a back saw because it has a back bone or metal stiffener along the non-tooth edge to help keep the saw straight and true. This saw is also a precision tool. If there is a kink or bend in the blade, the cut will not be clean. When buying a back saw (or any saw), site down the tooth edge and see if the saw is straight. It is very hard to find a straight saw these days- or a level level or a square square. The miracle of capitalist production again. Be picky. The good carpenters I know are finicky perfectionists. They take tools back to the store as many times as they have to until they get one that's right.

You can't do good work if your most basic tools aren't good and true. A good tool doesn't have to be expensive (although they usually are); it must be what it is supposed to be: square, level, flat, straight, etc.

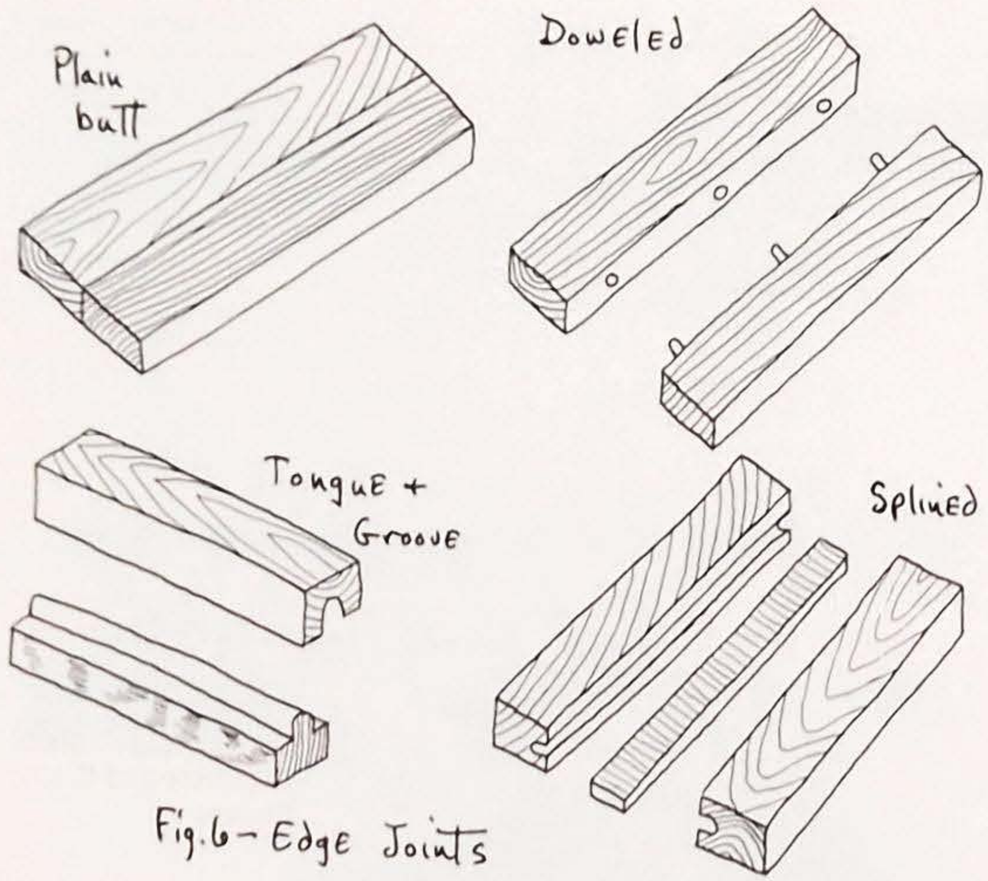


Fig. 6 – Edge Joints

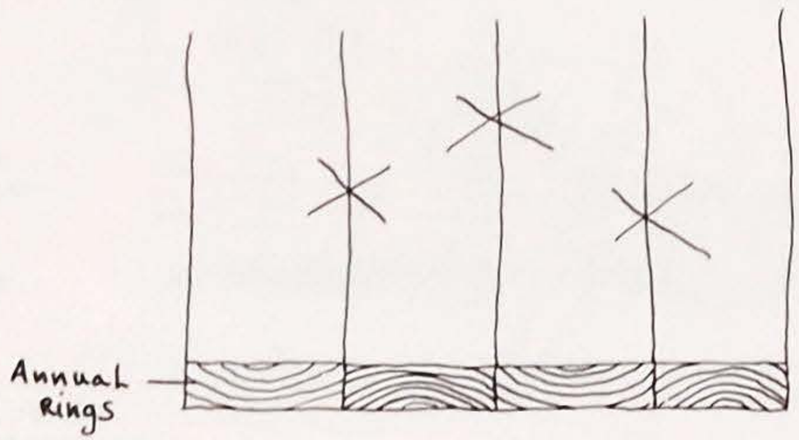


Fig. 7 – Laying out an Edge Joint

EDGE JOINTS

Another variation of the butt joint is the plain edge joint. If dowels are used, it is called a doweled edge. The strongest edge joint is the splined joint--especially when the grain of the spline runs across the joint. Fig. 6.

If you were to make a table top out of several 1"x6"s, the joints between the 1"x6"s will be some form of edge joint: butted, doweled, splined, rabbeted, tongue and groove.

Layout

To lay out an edge joint, arrange the pieces of wood the way you want them in the final assembly: match the grain and arrange the pieces so the grain of each piece runs in the same direction. The curve of the annual rings should be facing the opposite direction from the pieces adjacent to it. Align and square up the ends of the boards and mark an X lightly with chalk or pencil over each edge joint. Fig. 7.

Fitting The Joint

Chances are that two adjacent pieces do not fit snugly together for the whole length of the joint. To make the edge joint tight, clamp the two pieces together with their edges and ends even and the finish surface facing out. Plane both edges at the same time with a long plane such as a jack or smooth plane until you are able to plane off a light, thin, perfect shaving along the whole length of the edge. The edges will now fit together pretty well, even if the edges have been planed at an angle, and any further planing that must be

done is done to each piece separately. Fig. 8.

Gluing The Joint

When all the pieces have been planed, and if the joint is to be a butt edge joint, the pieces can be glued and clamped together. Apply a bead of glue (polyvinyl will do) to one edge of one of the pieces, then take this piece and rub the glued edge along the non-glued edge of the piece that will butt to it. This procedure spreads the glue on both edges. Continue this until all edges are spread with glue. Lay the pieces finish surface up (with X's aligned) on two or three (depending on how big the project is) bar or pipe clamps and tighten them by turning the cranks. Another clamp should be laid on top of and over the assembly with a piece of wood, cloth or towel protecting the finish surface from being marred by the metal and the corrosive action that polyvinyl glue has on the metal in the clamp.

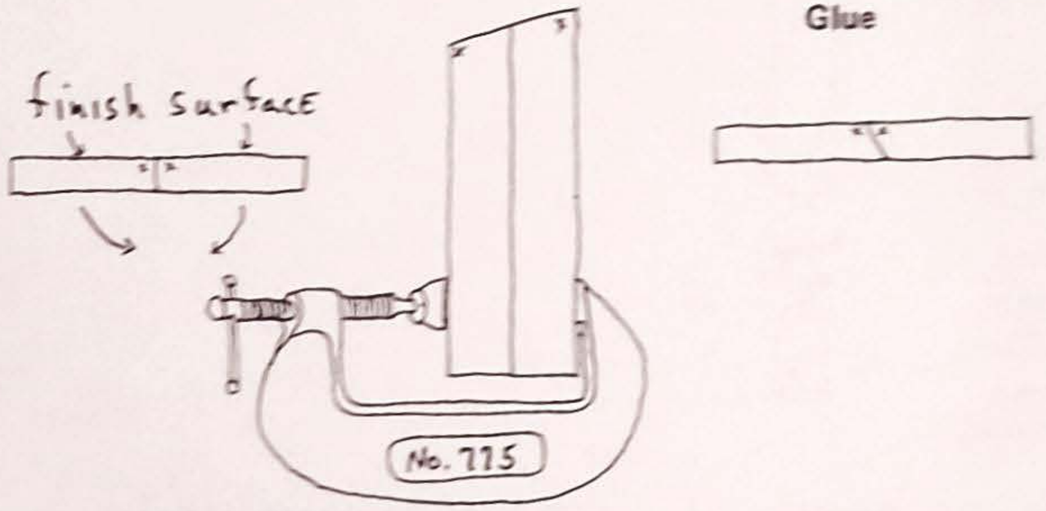


Fig. 8 – Clamping Boards for Edge Planing

Polyvinyl glue–See Metal Fasteners and Glues: Glue

Clamps–See Metal Fasteners and Glues: Clamps

Finishing The Joint

If you have put the right amount of glue on the edges, a narrow bead (1/16") of glue will squeeze out along the length of each joint. The excess is scraped off later with a cabinet scraper or hand scraper after the joint has set up. Polyvinyl glue will set up in 30 minutes, but the joint will not have its full strength for a couple of hours. Do not plane or sand the surface until the moisture from the glue that has been absorbed into the wood has had a chance to evaporate (a couple of days). If the joint is planed while the wood is expanded from the moisture in the glue, the wood will have depressions where it has been planed after it re-

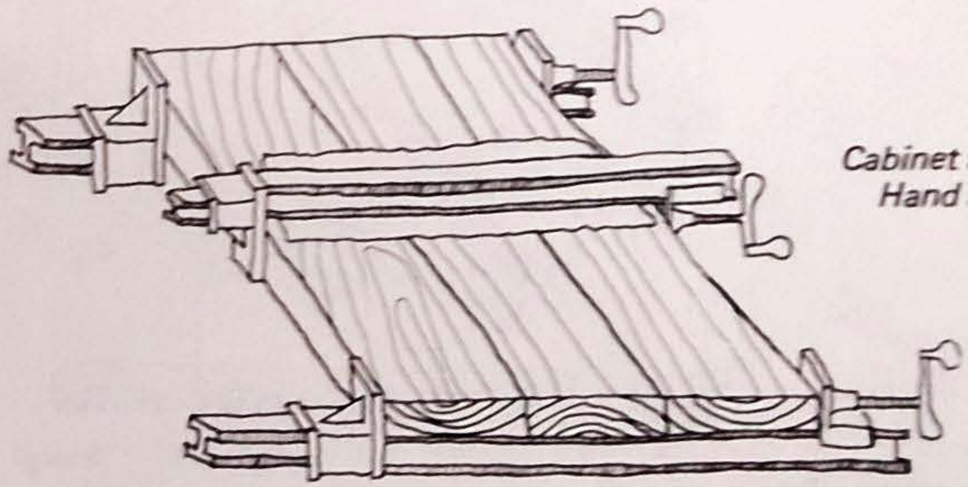


Fig. 9 – Clamping an Edge Joint

Cabinet scraper
Hand scraper

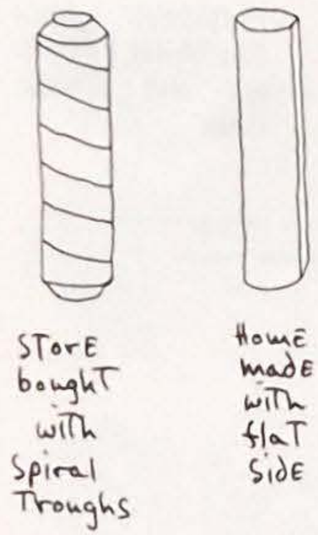


Fig. 10 - Dowels

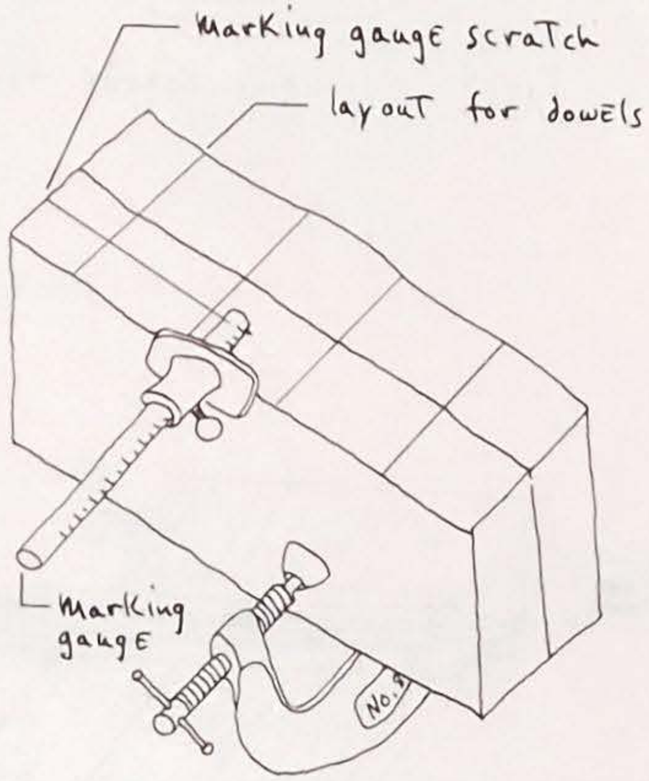


Fig. 11 - Marking the center of the Dowel holes with a marking gauge

Doweling Jigs--See This Chapt: Fig. 12

Marking gauge--See This Chapt: Half lap Joints (corner lap)

turns to its normal moisture content.

DOWEL JOINTS

If the edge joint is to be a doweled joint, then after planing the edges and while the two pieces are still clamped together with the finish surfaces facing outward, the layout for the dowels is made.

Dowels should be placed 4" to 6" apart in an edge joint. The thickness of the dowel should be one half the thickness of the wood it will be in. The dowels should be seated in the wood to a depth of two and one half times their diameter. The hole which the dowel will fit into in the other piece of wood should be 1/16" deeper than one half the dowel length protruding from the other edge. Store bought dowels have troughs spiraling around the length of the dowel. As the dowel is pushed into the hole, the glue travels through the troughs up the length of the dowel. If you are using a plain dowel without spirals, flatten one edge of the dowel a little by rubbing it on sandpaper. If regular cylindrical dowels are used without alteration, the glue will be pushed to the bottom of the hole by the dowel and there it will remain. The joint will be much weaker.

Square across the edges of the two clamped pieces at the places where you want the dowels to go. Now use a marking gauge to scratch a line in the edge where the centers of the dowels will be.

A marking gauge is a tool that is designed to mark lines parallel to a surface or edge. It has a small table which slides along the surface of the wood while a rod with a needle embedded in it scratches a line in the edge. The rod is adjustable and is held in place with a set screw. Set the marking gauge to 1/2 the thickness of one piece of the wood and mark the center of each dowel hole by pulling the marking gauge along the finish surface of each board. Fig. 11. A scratch mark will be put in each edge and the places where this scratch and the lines squared across intersect are the center of the holes to be drilled for the dowels. Drill the holes as perpendicular with the edge surface as you can using a bit that is the same size as the dowels you are using. (If the dowels are 3/8" in diameter, use a 3/8" bit.)

Put some glue in all the holes in one piece and tap the dowels into the holes lightly with a hammer. Put glue in the other set of holes, unclamp the pieces and spread glue on each edge as in the butt edge joint. Fit the dowels already in the one edge, into the holes in the other; and clamp the pieces as you would for a butt edge joint.

Doweling Jigs

If you want the surfaces to fit together perfectly, then a doweling jig, which guides the bits into the surface at right angles, should be used. A marking gauge is not necessary if a doweling jig is being used. The jig is calibrated so that the center of different thicknesses of wood is found easily. The doweling jig comes with a set of drill bit guides which are clamped into the jig

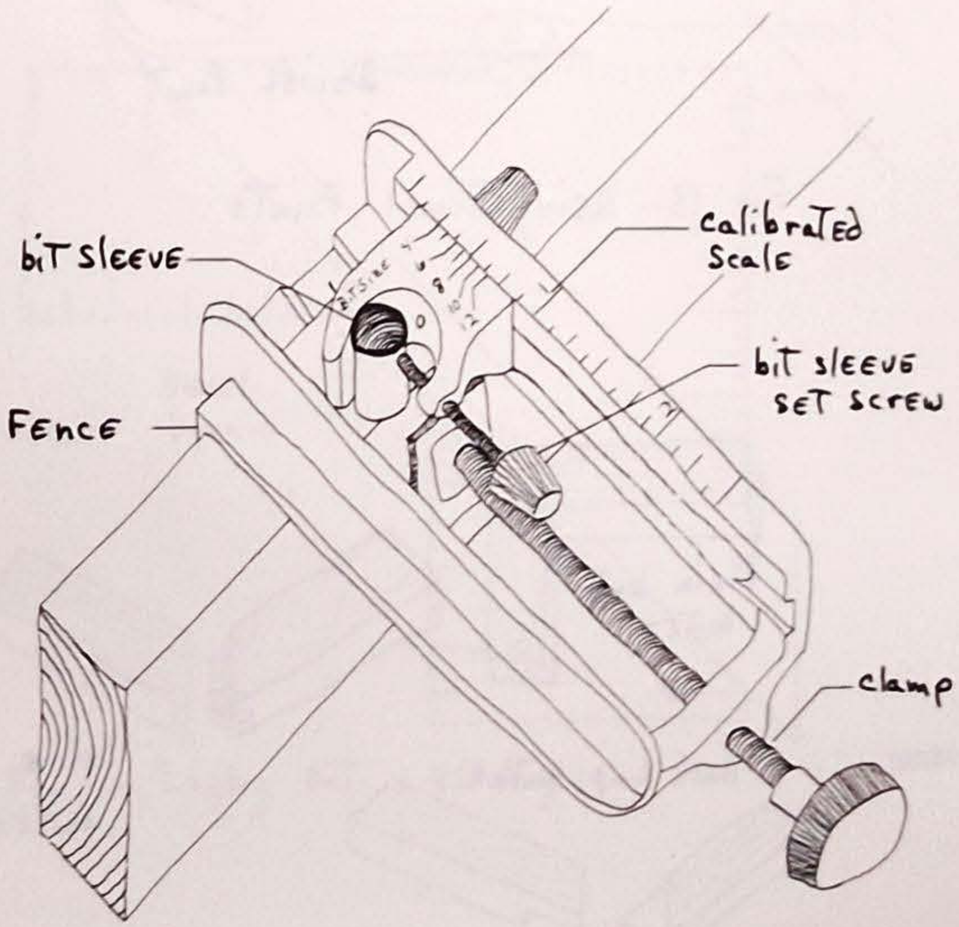


Fig. 12 – A Doweling Jig

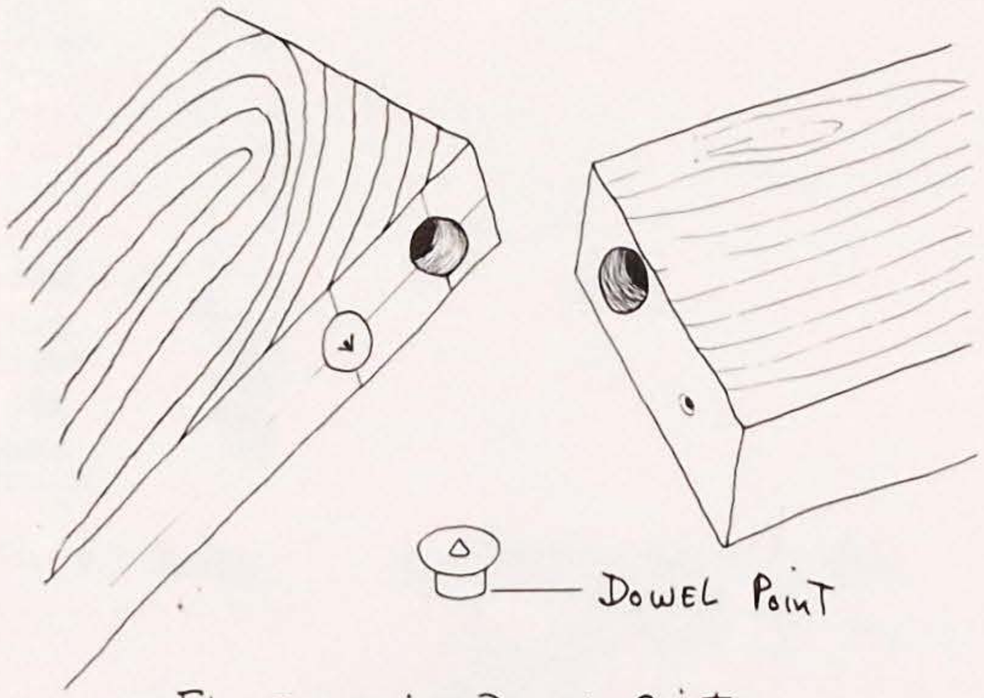


Fig. 13- Using Dowel Points

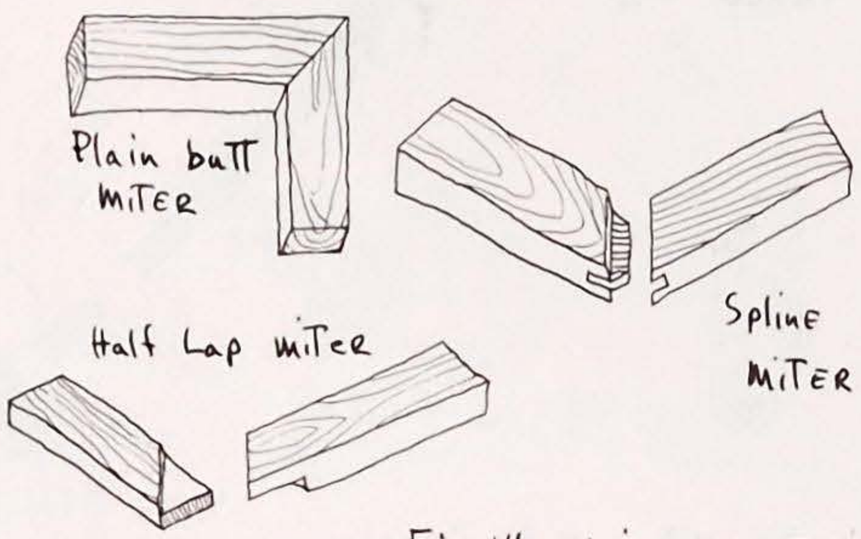


Fig. 14- Miter Joints

and guide the bit down into the wood perpendicular to the surface. The jig can be used with the pieces still clamped together or separately on each piece. In either case the fence of the jig must be clamped on the same side (either finish or reverse side) for both pieces. If the fence were to be clamped to the finish side of one piece and the reverse side of the other, and if the bit guide were off center even just a hair, the surfaces of the wood when finally assembled would be uneven by twice that much. (Two hairs.) If the fence is clamped to the finish side of both pieces, any errors in centering are canceled out.

Dowel Points

Dowel points or centers are little buttons with sharp points in their centers. They are made to fit into different diameter holes (1/4", 3/8", etc.). The dowel points are placed in the dowel holes in one member of a joint and it is aligned with the other in the correct joint layout. When the two pieces are pushed together, the indentation of the dowel point is clearly marked in the butting member. The indentation marks the center of the hole to be drilled for the dowel.

MITER JOINTS

Miter means to cut at an angle. The miter or angle cut on each member of a joint is one-half the angle formed by the joining of both members. A miter joint is usually made up of two 45° angle cuts on boards that come together in a right angle.

The mitering angle for any equal sided figure can be found using this formula:

$$\text{mitering angle} = 90^{o} - \left(\frac{180^{o}}{\text{number of sides}}\right)$$

$$X = 90^{o} - \frac{180^{o}}{8} \quad \text{(for an octagon)}$$

$$\text{mitering angle} = 67\tfrac{1}{2}^{o}$$

A 45° angle can be laid out on any board by using the framing square and a bevel square. Hold the body of the bevel square along one outside edge of the framing square near the heel. Move the bevel square until the blade intersects the same number on the outside of the tongue and blade of the framing square (3 and 3, 4 and 4, etc.). Tighten the nut or screw on the bevel square so the angle is held securely and the square is set to a 45° angle. This method is based on the principles of a right isosceles triangle: angles opposite equal sides (3 and 3 or 4 and 4) are equal. Since one angle of the triangle is 90° and all the angles in a triangle must add up to 180°, the other two angles when added must equal 90°. Since they are equal angles, they must each be 45°.

Bevel square

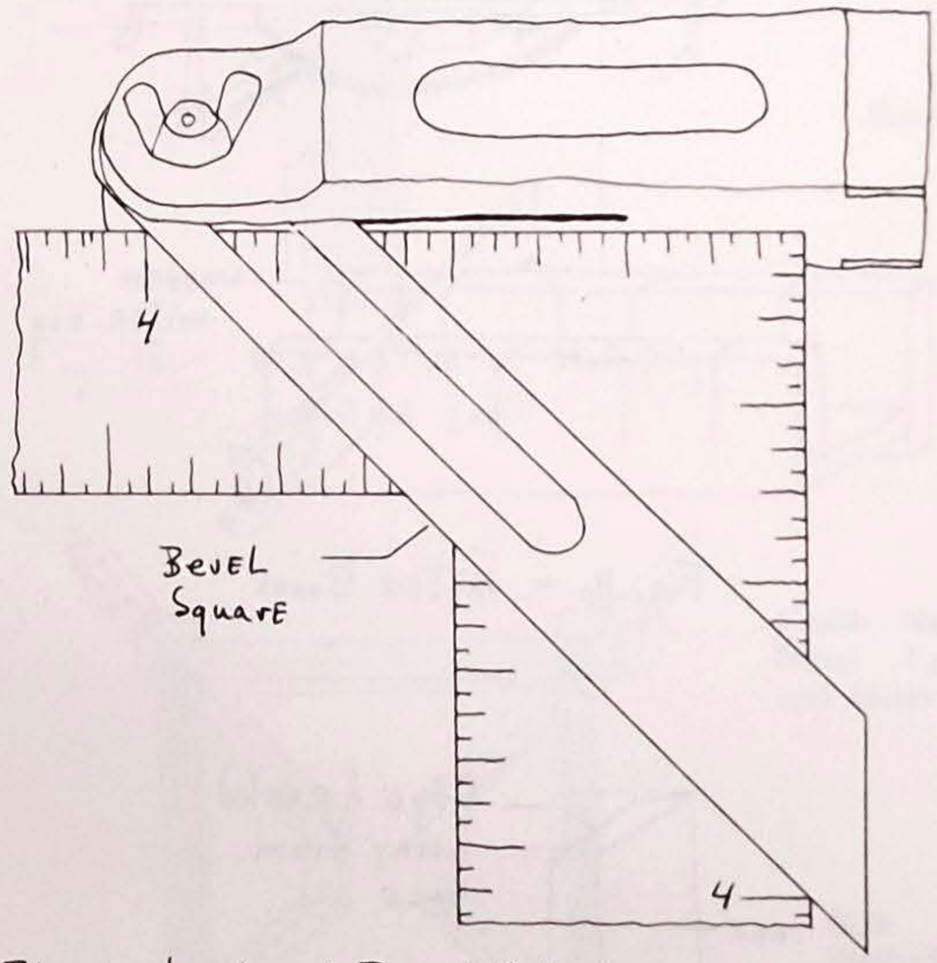


Fig. 15 – Laying Out a 45° Angle

Cutting The Angle

The miter cut can be made by clamping a guide block at the correct angle on the material to be mitered and making the cut with a back saw held snugly against the guide block.

A miter box can also be used to cut miter joints. Miter boxes vary from inexpensive wooden

Miter box

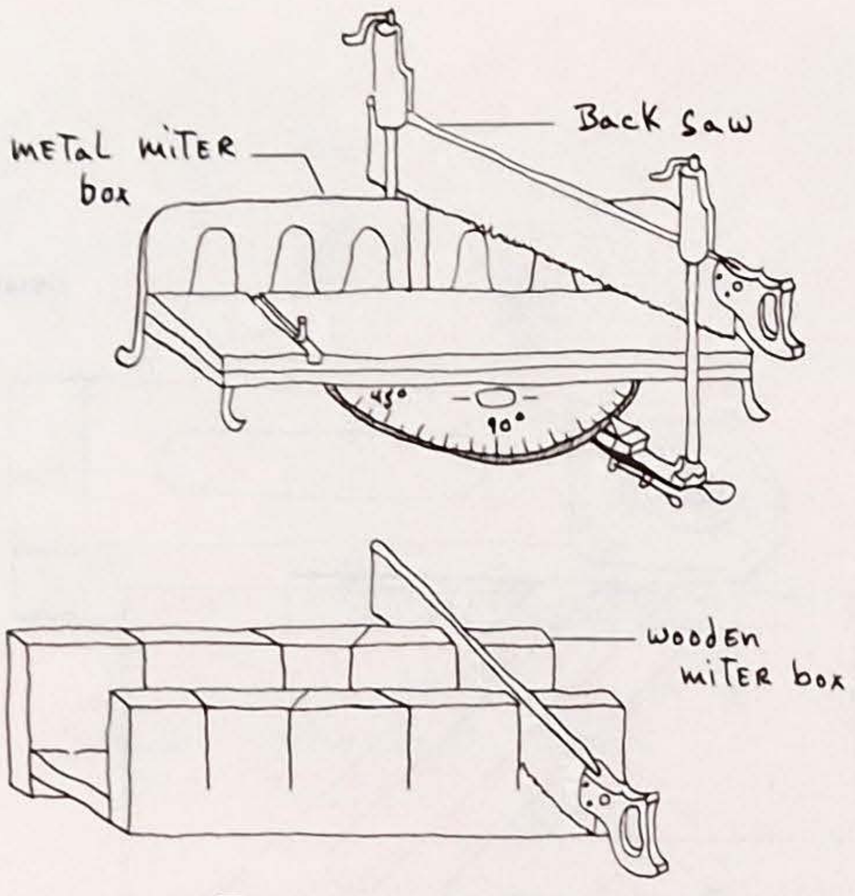


Fig. 16 - MITER Boxes

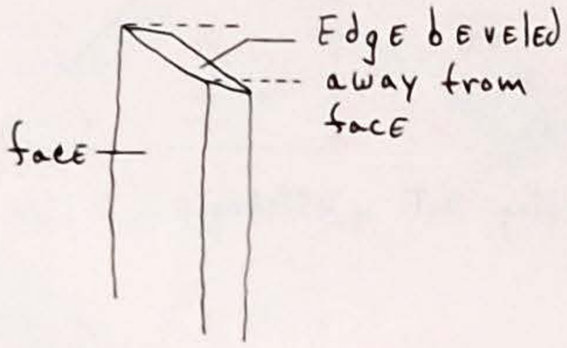


Fig. 17 - Planing a MITER

boxes made of a hardwood such as maple to elaborate metal boxes costing over $100. Any angle can be cut with the metal miter box which is calibrated by degrees like a protractor. The devise that guides the back saw can be locked into any angle. The material to be mitered is placed on the bed of the miter box and held tightly against the back wall. For exact work the material should be clamped so that it doesn't move while you are sawing. Wooden miter boxes have guide cuts only for 45^{o} and 90^{o} angles, but guide cuts for any other angle can be made by sawing the cuts into the box at the desired angle.

Fitting The Joint

After both miter cuts have been made, hold the joint together around something square like the framing square. If the intersection isn't clean, plane a little off one mitered edge with a block plane.

Hold the plane so that it cuts the edge of the cut on a bevel away from the face side of the miter--this prevents the plane from taking a gouge out of the finish side of the miter and marring the joint. Beveling the back side of an edge is a good way to make any butt joint fit neatly. Fig. 17.

One way of making a miter joint absolutely perfect is to clamp it together and run a saw kerf right through the miter joint. A guide block can

be clamped to the face side of the joint to help guide the saw. After the cut has been made, one side of the joint will be a mirror image of the other and the joint will fit together without any spaces in between.

Assembly

Miter joints in a frame or box need to be clamped while the glue is drying. There are patented clamps that hold a miter joint or a frame together while the glue is setting. A band clamp works well on a box with miter joints.

If no clamps are available a small block can be glued to the outside edge of each member of the joint. A hand screw is applied to the blocks and tightened, bringing the joint together. After the joint has set up, the glue blocks are split off. Fig. 18.

You can also design and build your own miter or frame clamp. Fig. 19. A clamp such as a wood screw is applied to the two pivot bars drawing them together and thereby tightening the miter joints.

In many cases if the joint is a butt miter, it is nailed or fastened with a corrugated metal fastener, a short corrugated strip of metal that is sharpened on one edge for driving down into wood. The miters in door and window trim are usually nailed through the miter joint from at least one member--this helps compensate for any variation in the sheetrock that might make the joint uneven.

The finish nails should be set with a nail set and the corrugated fastener is driven into the reverse side of the frame because it mars the surface.

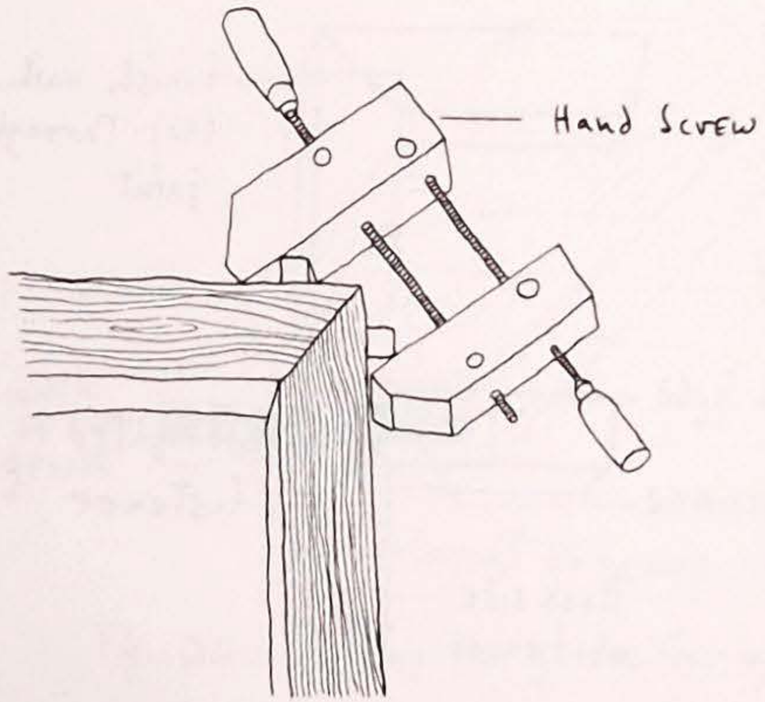


Fig. 18 — One Method of Clamping a miter joint

Band clamp

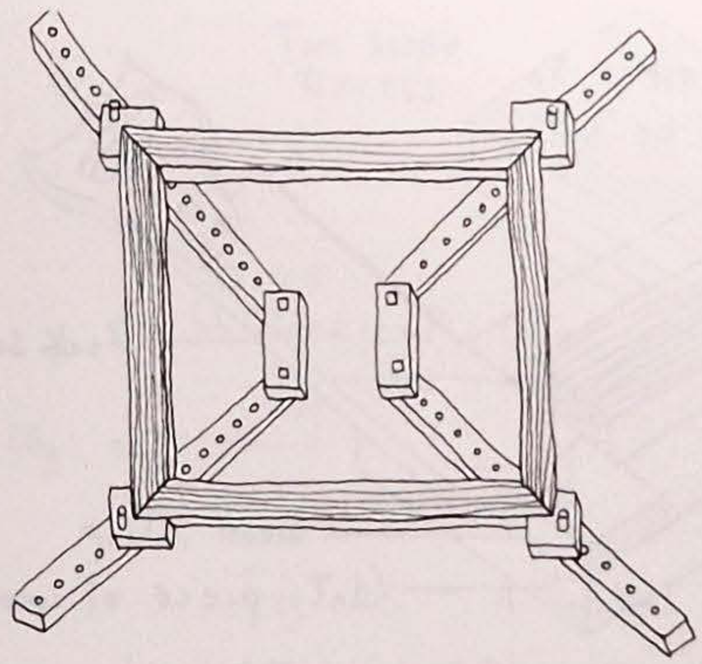


Fig. 19 — a Homemade Frame Clamp

Finish Nails--See Metal Fasteners and Glues: Fig. 1

Nail set--See Walls: Paneling

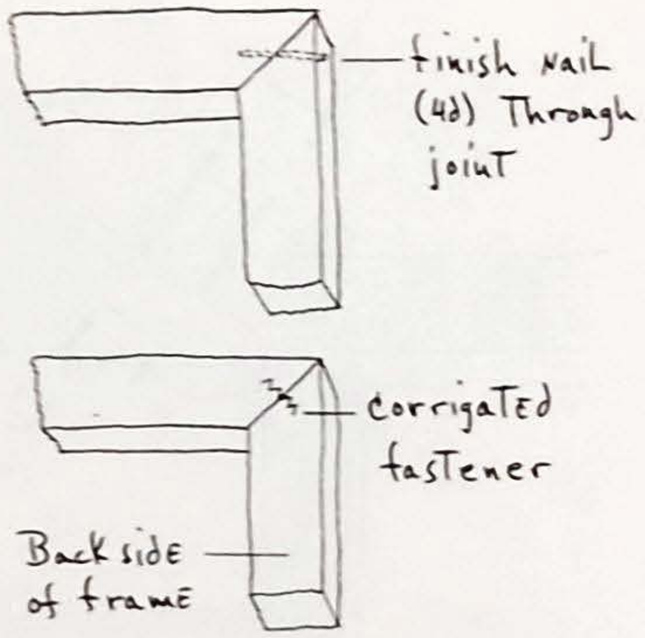


Fig. 20 – Fasteners in miters

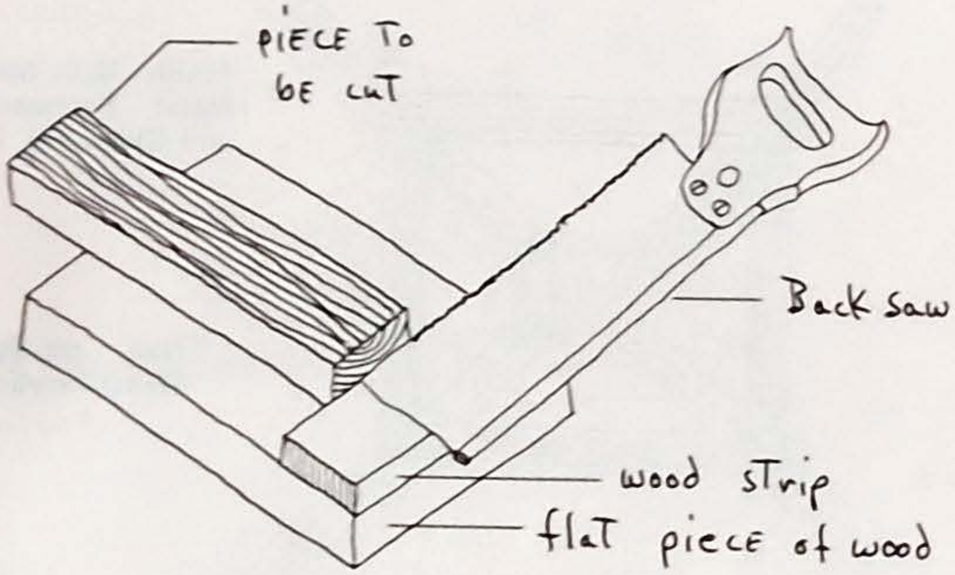


Fig. 21 – Edge cutting jig

All miter joints should be glued whether or not metal fasteners are used.

SLIP FEATHER JOINT

Slip feather

Saw kerf--See Tools: Fig. 6

Butt miters do not hold extremely well, even when nailed. A slip feather joint is much stronger. A slip feather, a thin piece of wood or veneer, is similar to a spline in function (Fig. 14.) and is glued into a saw kerf cut into each edge (thickness dimension) of the miter cut. The saw kerf must be perpendicular with the edge of the miter cut.

To make this kind of cut into the edge of a board, an edge cutting jig should be used. An edge cutting jig can be constructed by gluing a 1"-2" wide strip of wood to a larger piece of wood that is perfectly flat. In order to center the edge cut, the thickness of this strip should be equal to one-half the width of the saw's kerf. The broad side of the back saw blade is held snugly against the wood strip while the edge cut is made.

After a saw kerf has been cut into the edges of both members, apply glue to both sides of the slip feather, push it into the kerf of one member of the joint and then into the other while assembling the joint. Clamp the joint until the glue dries and then if there is any part of the slip feather extending beyond the edges of the wood, take it off with a chisel.

SPLINE JOINTS

A splined joint operates under the same principles as a slip feather joint--the difference is that the spline is much thicker than the slip feather. Fig. 14. For miter joints lay out the outline of the groove on the edges of the mitered pieces. The goove should be as wide as the spline is thick. The groove can be hollowed out by drilling a series of holes the length of the groove layout with a bit whose diameter is equal to the width of the groove. After the holes have been bored to a depth equal to one-half the width of the spline, a chisel is used to take out the remaining wood and smooth the walls of the groove. Fig. 22.

The spline joint is assembled like the slip feather joint. The grain of the spline should run across the joint to make the joint stronger.

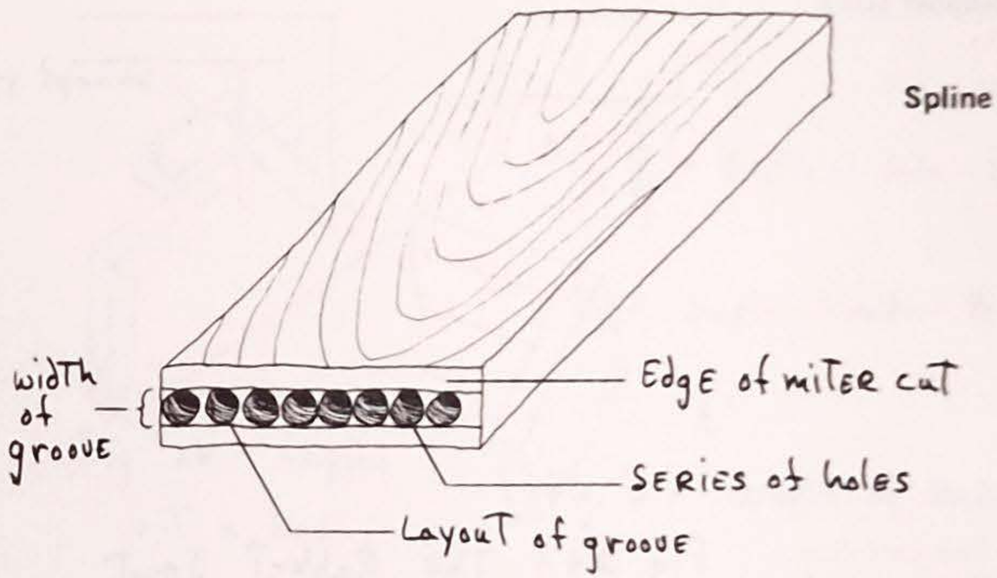


Fig. 22 - Cutting the groove for a Spline

RABBET JOINTS

A rabbet is a two sided recess running along an edge of a piece of wood. When another board butts to a rabbet, a strong good-looking joint that is used a lot in cabinets and furniture, is formed. Any joint that includes a rabbet in one or both members is a rabbet joint. Fig. 24.

A rabbet consists of two cuts: a shoulder cut and an edge cut (Fig. 23.). If there is to be only one rabbetted member in the joint, as in Fig. 24B, then the distance from the edge to the shoulder cut will equal the thickness of the other member of the joint. If each member in a joint is rabbetted as in Fig. 24A, the distance from the

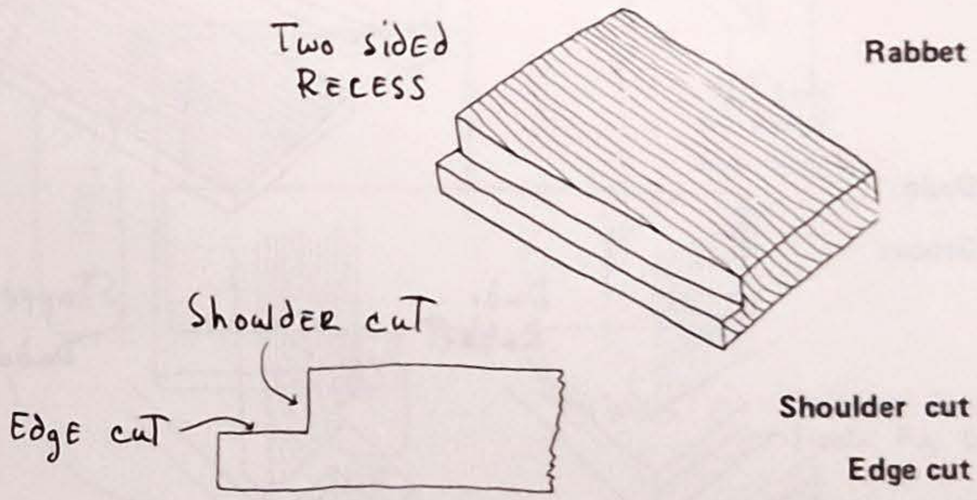


Fig. 23 – A Rabbet

Rabbet plane

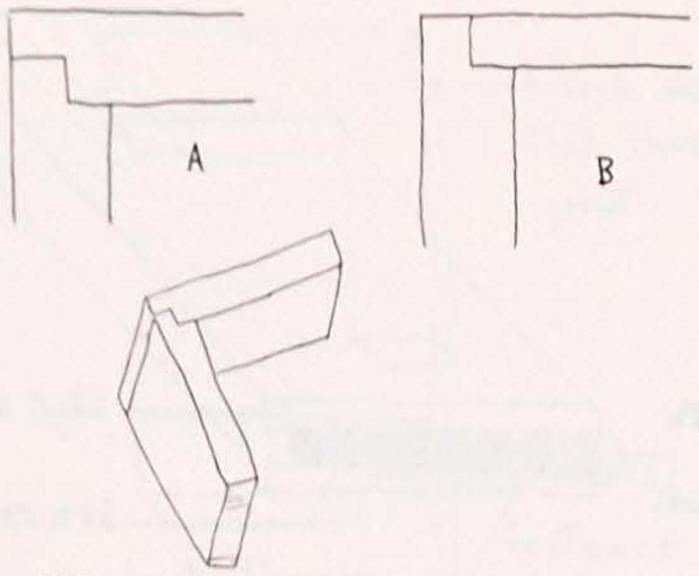


Fig. 24- The Rabbet Joint

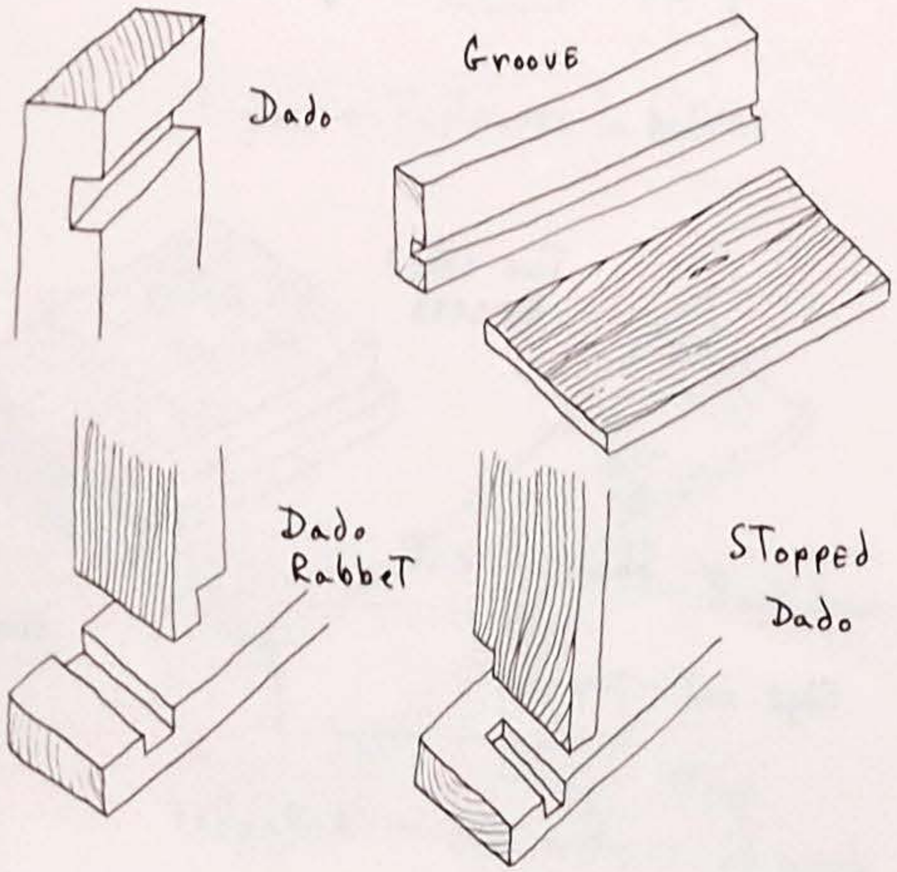


Fig. 25- Dado Joints

edge of each piece to the shoulder cut is equal to one-half the thickness of the wood (if they are of equal thickness and if each rabbet is the same).

The shoulder cuts are made as previously described in the section on Butt Joints with a back saw and a guide block. The only difference is that the cut does not go all the way through. The edge cut is made using an edge cutting jig and the same techniques described in making the edge cut for a slip feather joint are used. The sides of the recess can be smoothed with a chisel or a rabbet plane. A rabbet plane is a plane whose cutting edge runs across the entire plane bottom making it possible for it to plane into corners.

Rabbet joints can be nailed, screwed or glued. If nails or screws are to be used, the depth of the shoulder cut should be one-half the thickness of the wood. If the joint is to be glued, the depth of the shoulder cut can be 2/3 the thickness of the wood.

DADO JOINTS

A dado is a three sided recess running across the grain. A groove is a three sided recess running with the grain. Dados are cut in stair stringers and shelf supports to be joined with treads and shelves in a very strong joint (dado joint) which can hold a lot of weight. Drawer bottoms are joined to drawer sides by a grooved joint.

Laying Out A Dado

If the dado is to be part of a shelf structure, then each pair of dados that will hold up one

shelf should be laid out together. Clamp the two shelf uprights together with the sides that will be dados facing each other. The position and depth of the dado should be laid out on one edge. Fig. 26. Unclamp the two pieces of wood and lay out the dados on the width dimension of the shelf supports. Square the lines across with a framing or try square.

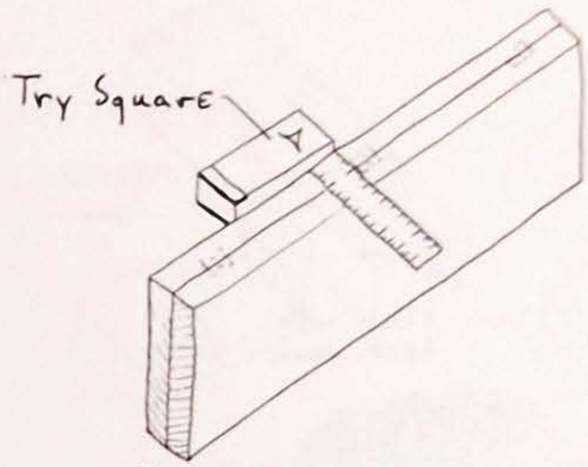


Fig. 26 - Laying out a Dado

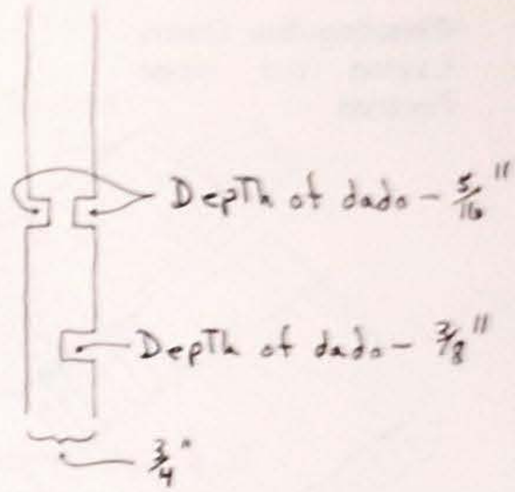
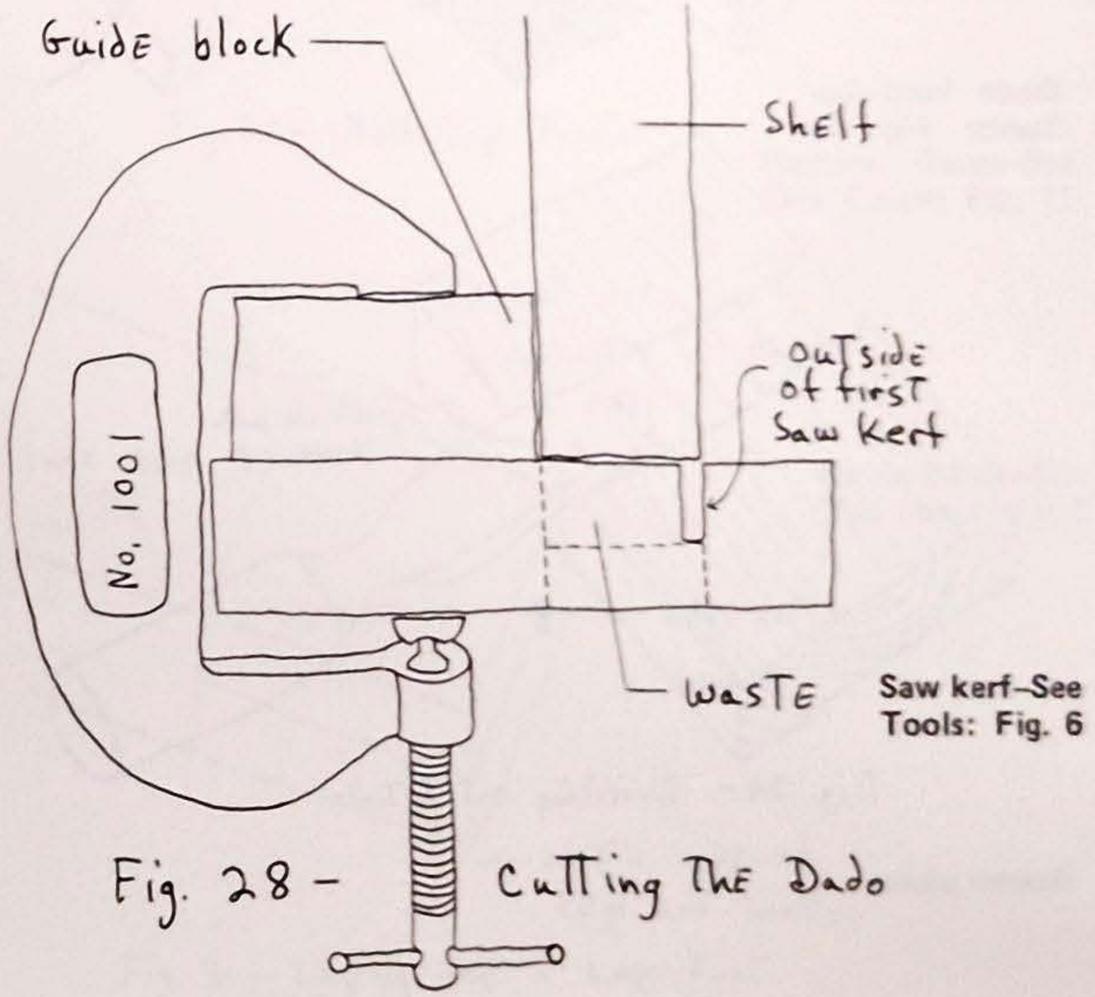


Fig. 27 - Depth of Dado

Cutting A Dado

Clamp a guide block along one of the layout lines across the face and make the cut with a back saw as previously described in cutting a square butt joint. Make sure the kerf is on the waste side of the line toward the center of the dado. Usually the depth of a dado (or groove) is one-half the thickness of the wood, but if two dados are located back to back in a shelf upright, the depth of the dado should be reduced so that the strength of the upright isn't compromised. Fig. 27.

When the first cut has been made, move the guide block over and align it with the second layout line. Hold the piece of wood that will go into the dado (a shelf in this case) up to the dado layout and use it to align the guide block for the next cut. Align one side of the shelf with the outside edge of the first saw kerf. Position the guide block up to the other side of the shelf, clamp it tightly, and make the second cut. Fig. 28.



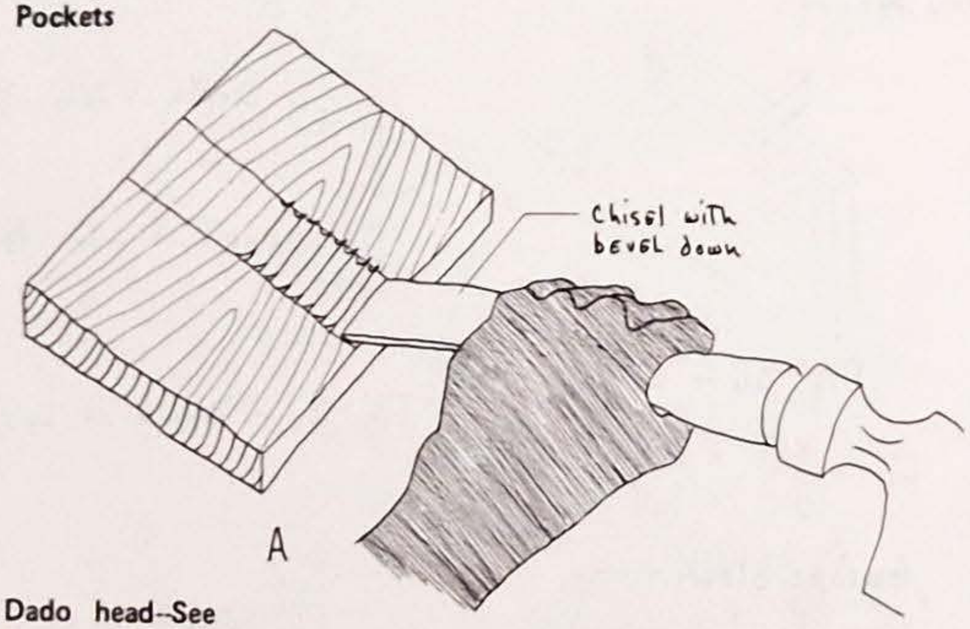
Saw kerf–See Tools: Fig. 6

Fig. 28 - Cutting The Dado

Chiseling Out The Dado

The wood remaining between the two saw kerfs can

Chiseling–See Doors Laying out hinge Pockets



Dado head–See Stairs: Fig. 13

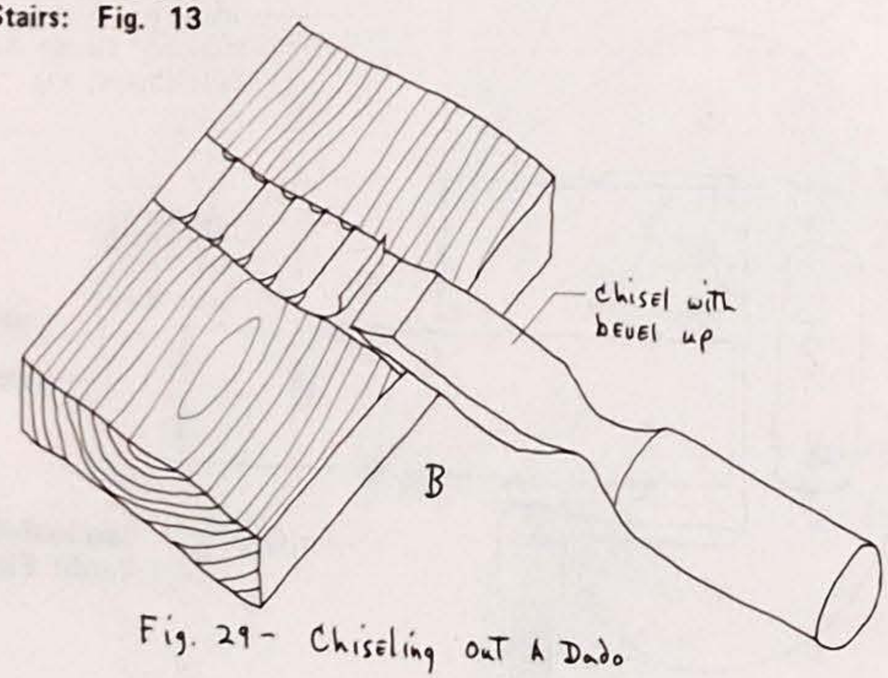


Fig. 29- Chiseling out A Dado

Router plane

be removed with a chisel. Leave the guide block clamped in place to help guide the chisel. Make a series of rough cuts with the bevel of the chisel down (toward the wood). Fig. 29A. Then turn the chisel bevel over so that it is up and with the flat side of the chisel down, scrape out the chips you have started. Continue in this way, first making rough cuts then scraping them out until the proper depth has been reached. Depending on the hardness of the wood, the rough cuts should be 1/8"-3/16" deep so when the chisel is turned over and used to pare out the rough cuts, 1/8"-3/16" of wood should be taken out each time.

Another way to remove the wood within the dado is to use a dado head on a circular saw and make a few cross cuts carefully between the outside cuts of the dado. This can be done by hand too. Use a chisel to chip out the wood remaining between the kerfs.

The bottom of the dado can be smoothed out with a chisel or a router plane if you have one. If the shelf doesn't fit into the dado, it is better to sand or plane the edge of the shelf to fit the dado, than it is to try to widen the dado to fit the shelf.

HALF-LAP JOINTS

Half-lap joints are usually made up of pieces that are the same thickness. An equal amount of wood is taken from each member so that when the joint is completed, the surfaces of both members are flush. It is a very strong joint and is used in the corners of frames, joining legs and cross supports of tables, etc.

Corner Lap

Measure from the end of each piece a distance equal to the width of the other member of the joint and square this line (the shoulder cut line) completely around each piece.

Choose the best wide side of each piece and call it the face side. Set the marking gauge for one-half the thickness of the wood and scratch a line from one shoulder line along the edges and end of the wood to the other shoulder line. Be sure the guide of the marking gauge is resting on the face of each piece so that if the marking gauge is not set exactly to one-half the thickness of the wood the surfaces of both members of the joint will still be flush. Fig. 31.

Make the shoulder cut with a guide block and a back saw. Begin the cut from the face side of the lapped member and from the back of the lapping member. When sawing down from the face of the lapped member, saw through the edge cut line, but when making the shoulder cut from the back side of the lapping member saw to--not through--the edge cut line. Fig. 32.

Use an edge cutting jig to make the edge cuts on both pieces. The edge cut of the lapped member should take the line--that is, the line should be sawed away. The edge cut of the lapping member should leave the line--that is, the saw kerf should come up to but not through the line. This insures that the surfaces of the joint will be flush.

A line has a thickness that must be accounted for when doing finish work.

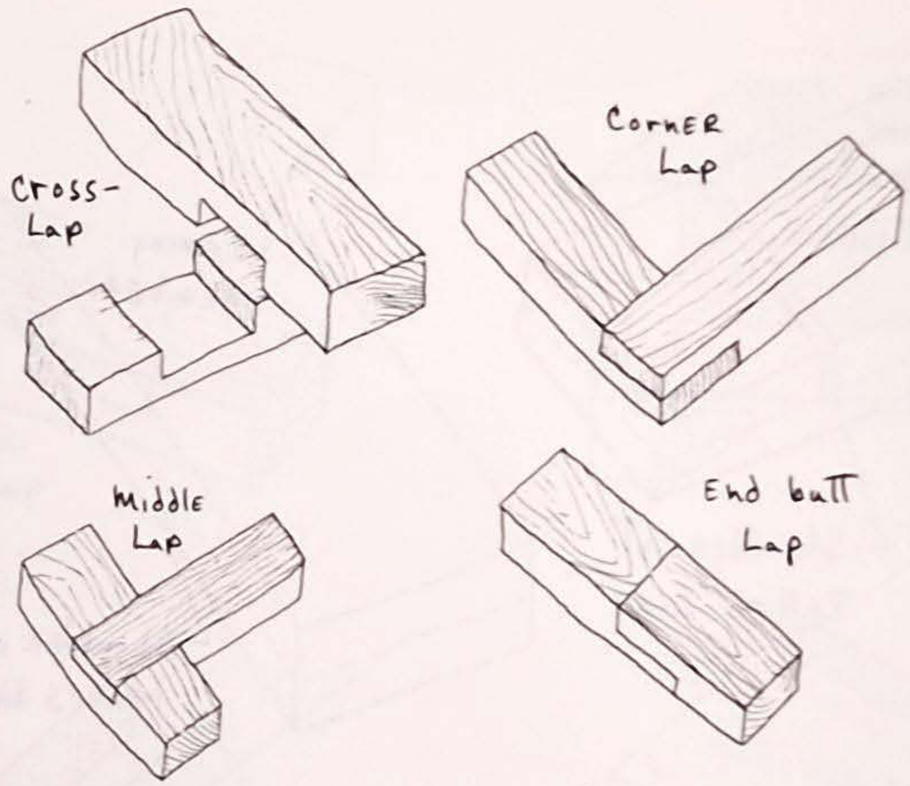


Fig. 30- Half Lap Joints

Marking Gauge–See This Chapt: Fig. 11

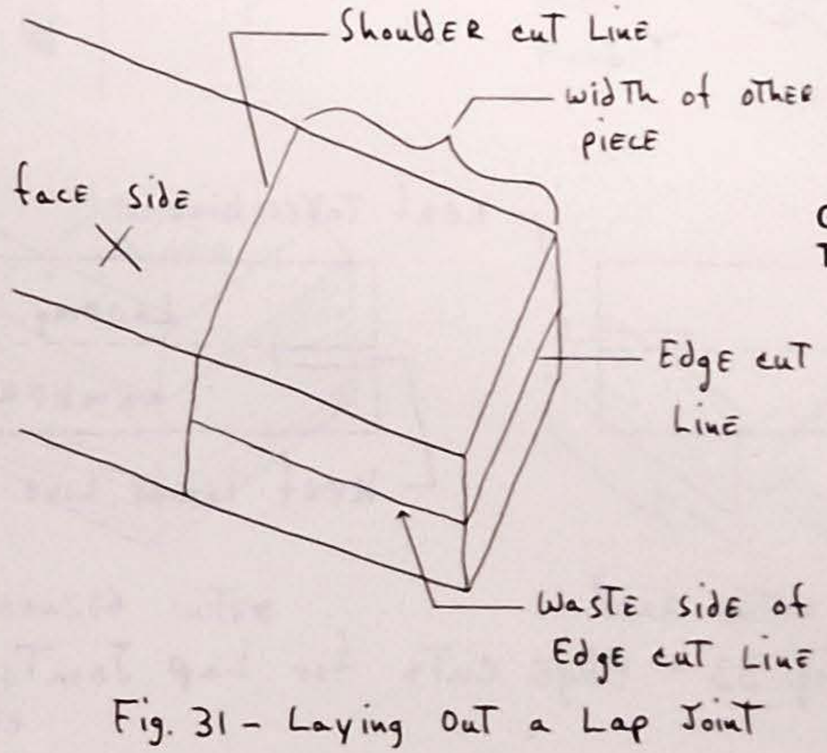


Fig. 31 - Laying Out a Lap Joint

Guide block–See This Chapt: Fig.3

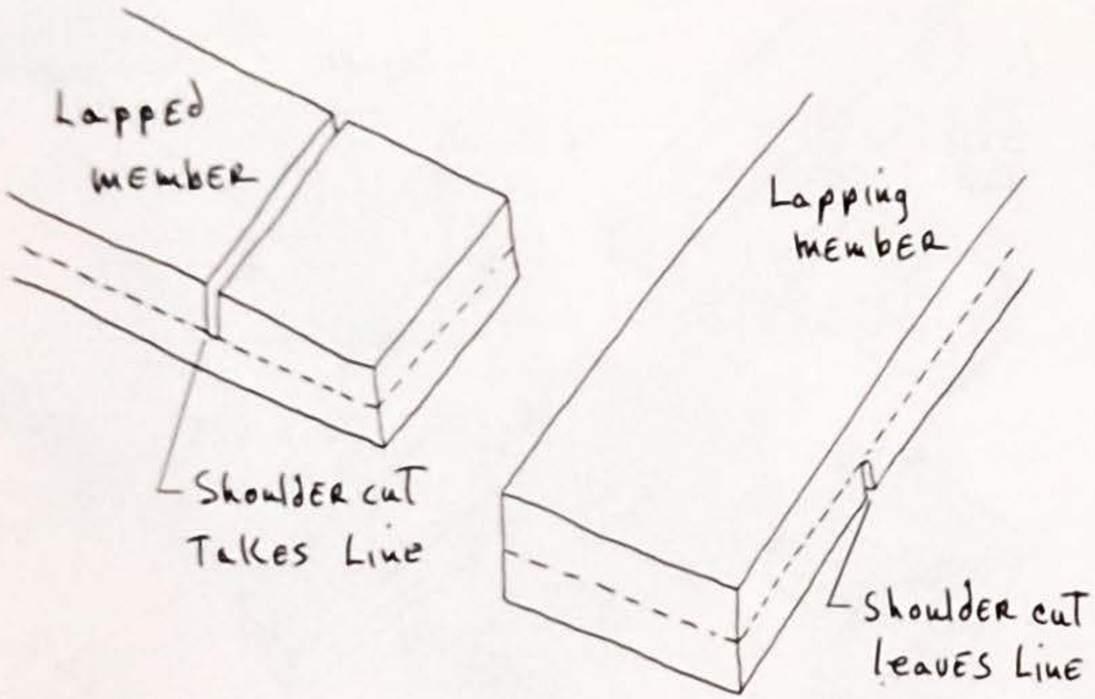


Fig. 32 - Shoulder Cuts for Lap Joints

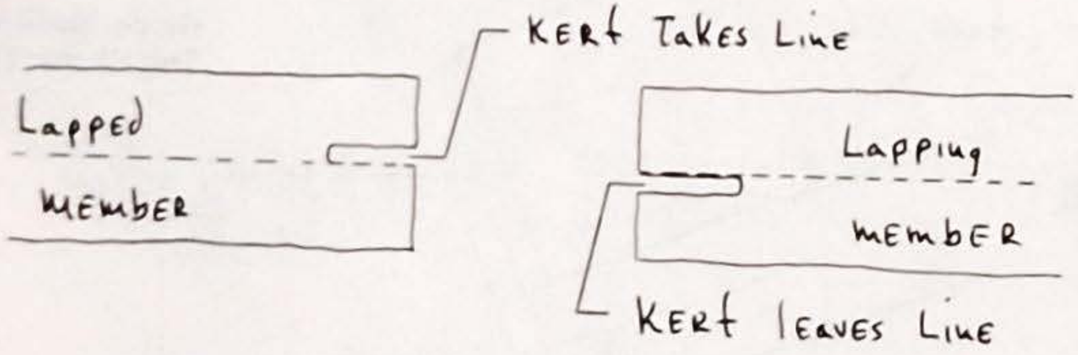
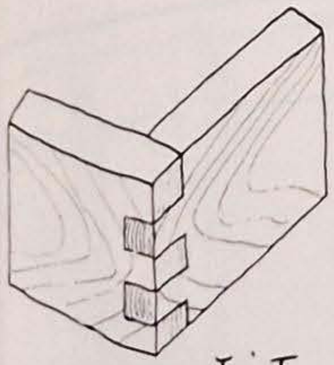
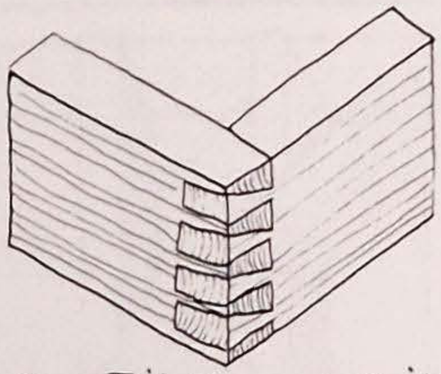


Fig. 33 - Edge Cuts for Lap Joints

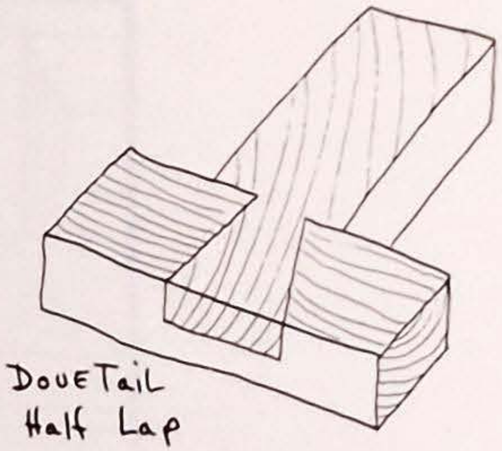
If the joint is assembled and the faces aren't flush, plane the bottom of the cuts with a rabbet plane or chisel.



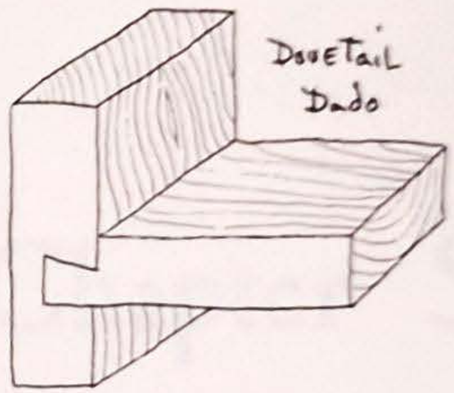
Box Corner Joint



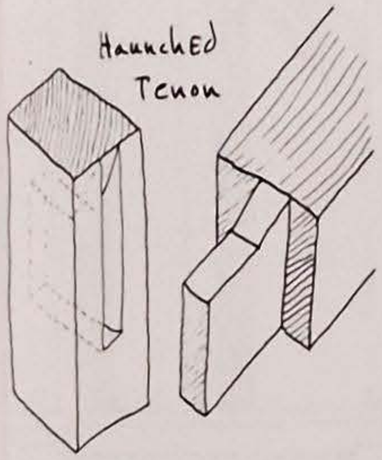
Dovetail Drawer Joint



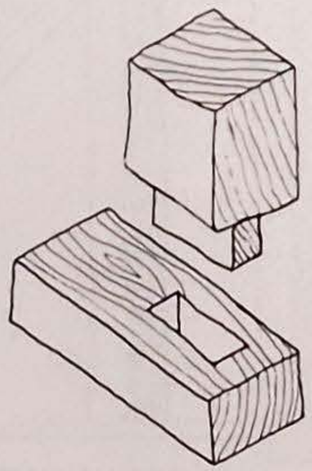
Dovetail Half Lap



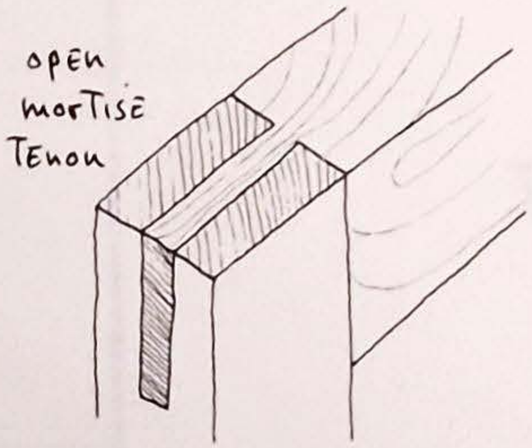
Dovetail Dado



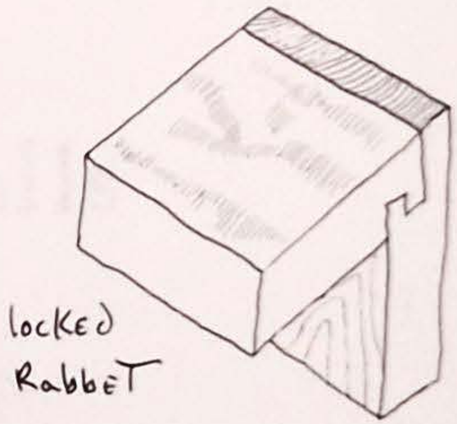
Haunched Tenon



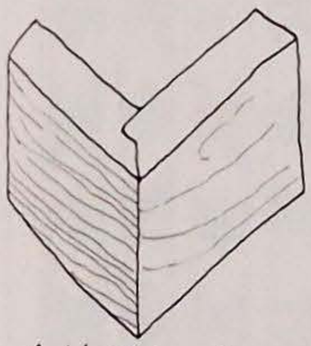
Stub Tenon



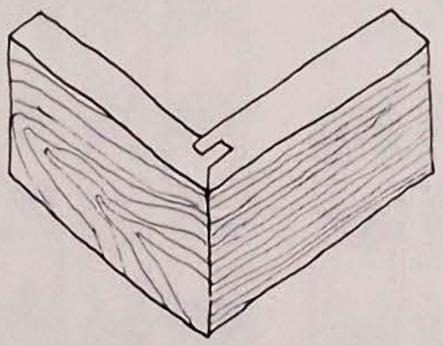
Open Mortise Tenon



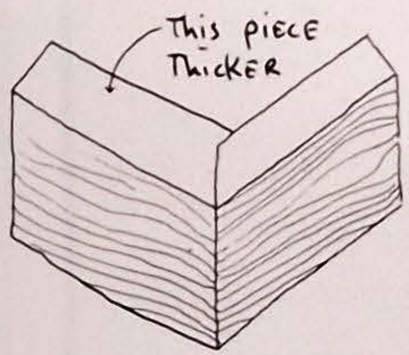
Locked Rabbet



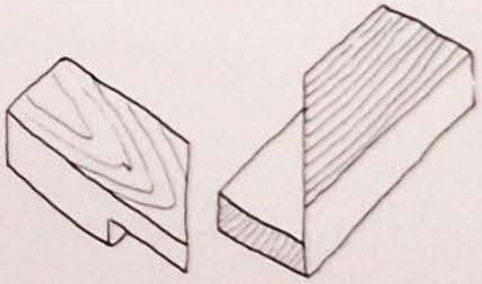
Rabbeted miter



Lock miter



Housed miter



face miter with half Lap

Fig. 34- Other Joints