Mortise and Tenon

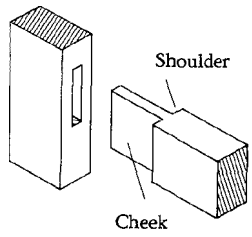
Choosing and making this basic joint

by Tage Frid

Furniture construction is broken down into two categories — frame and casegood. Casegood construction uses joints such as dovetails, finger joints, spline miters, rabbets and the like. Frame construction depends on the mortise and tenon joint and is usually used in tables, chairs, paneled doors, windows, etc. There are a great many variations of the mortise and tenon joint, and the task of the cabinetmaker is to know which variation to choose for a particular application, and why, and then how to make it quickly and well.

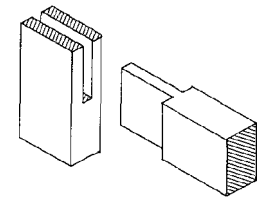
The mortise and tenon is probably the oldest and certainly the most essential joint in woodworking. An Egyptian sarcophagus now in the British Museum was framed with mortise and tenon joints at least five thousand years ago. During the Middle Ages, the development of the mortise and tenon permitted the framing of chests. The elaborate variations of paneling led finally to a distinction between the two crafts of carpentry and cabinetmaking. In house construction the use of the mortise and tenon has quite disappeared. We no longer have the skill or the patience, nor can we afford the mortise and tenon for the framing of a house. Perhaps we do not expect our houses to endure for much more than a few generations. But we do still find esthetic and practical satisfaction in a well-constructed piece of furniture.

The strength of the mortise and tenon joint depends entirely on the interplay between the cheek and shoulder of



the tenon, which is the projecting part of the joint. One can imagine two crossed boards glued together. Despite the holding power of the glue, they can be twisted apart relatively easily.

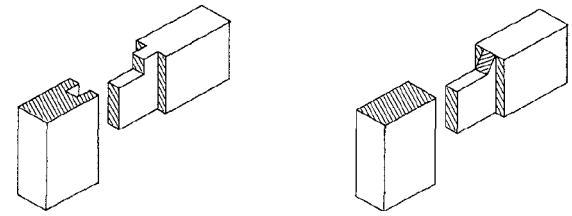
But connect them as a lap joint, and the strength is increased greatly because of the stop-action of the shoulders. Now double the surface area of the glue by making a slip joint



— a form of mortise and tenon — and we have an extremely strong joint that is easy to make and requires minimum tools.

The disadvantage of the slip joint is that not only do we have to clamp the tenon shoulder tightly against the mortise, (as in all mortise and tenon assembly), but we must use a second clamp to make sure the cheeks are glued to the mortise sides. Moreover, the tenon is completely exposed.

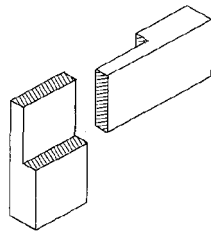
We get around these drawbacks by changing the slip to a

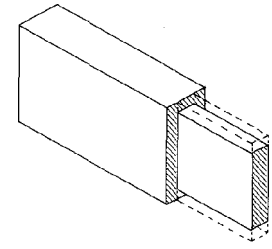


haunched mortise, or to a mitered haunched mortise where the tenon is completely hidden.

When designing a mortise and tenon joint, one should aim for the maximum glue surface. A tenon of about one-third the thickness of the stock is usually the best choice. If the tenon is thicker, the mortise sides become too thin; if the tenon is thinner, it becomes too weak. (But sometimes in table construction, where the leg is much thicker than the aprons, the aprons may have tenons half or more the apron thickness.)

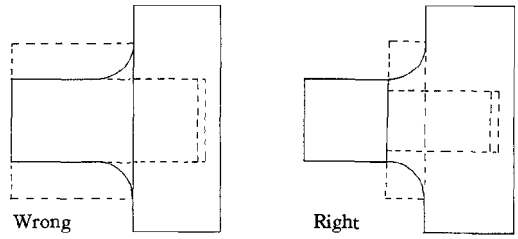
Four shoulders should never be used unless absolutely necessary. The joint becomes more difficult to fit because all





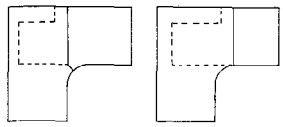
four shoulders must be precisely located in the same plane. Also, glue surface is lost. On the other hand, if the design calls for carving and material will be removed around the joint, four shoulders ensure that the joint will not be revealed.

If the design calls for round corners it is advisable to glue a block on, or to have the mortise stock wider. These provisions



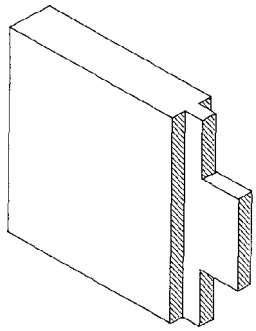
prevent problems with the end grain which will break and crumble, especially if carved.

There are two different ways to make a round corner in a frame. The left one is used if the inside corner is going to be



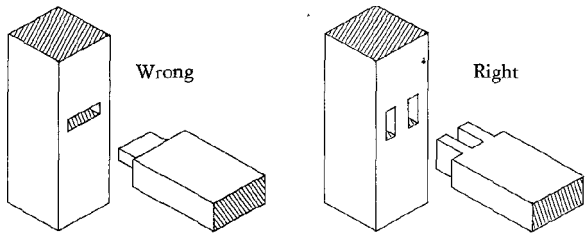
carved or shaped for a molding, and the right one is fine if the edge will be left straight, because then you don't have to worry about carving into the joint.

When a tenon is very wide, haunches should be put in at either end. A wide tenon is more difficult to glue as it



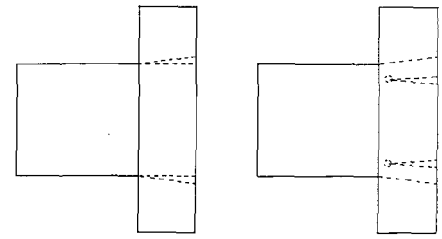
requires extra clamps for gluing the cheeks. But the haunches are necessary to keep the wood from twisting.

When a tenon is very narrow, the temptation is to run the tenon across the grain. But this should never be done because



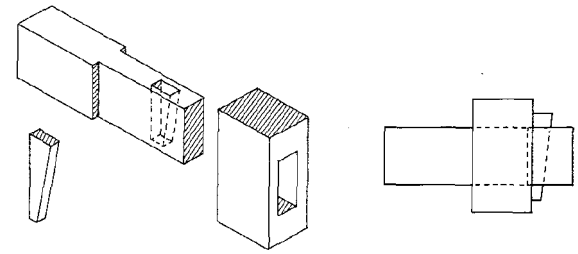
then the cheeks glue into end grain which is not a glue surface. The way to fasten narrow tenons is to use double (or triple) tenons, running the mortises in the direction of the long grain to provide good glue surface.

Wedges are used to strengthen the joint. When the tenon is cut to receive the wedge be sure to drill a small hole at the



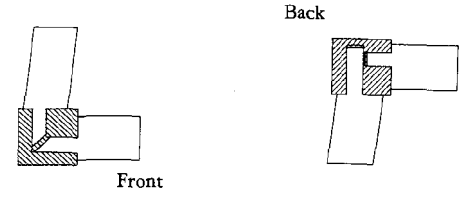
base of the saw cut to prevent cracking. When hammering in wedges in a through tenon, be sure to hammer evenly on each wedge so as not to force one half or the other too far which could result in splitting. If the tenon is to be hidden, use this method.

If a mortise and tenon is to be disassembled, a loose wedge is used. The wedge could be substituted with a wedged dowel



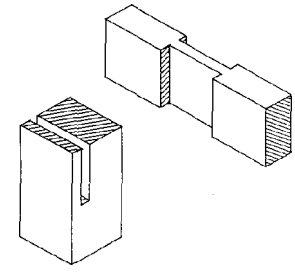
for the same effect. If the piece which receives the wedge is too thin, the two shoulders could be placed on the top and bottom instead of the sides.

In a chair, the back is usually one to two inches narrower than the front. This is done more for appearance than for any other reason. This requires the sides to angle into the back.



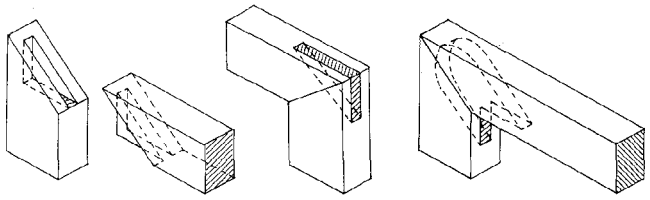
Usually the angle is made in the tenon, because it is easier than angling the mortise. Of course there is a limit to how much the tenon can be angled, but as long as some long grain reaches the full length of the tenon, it is safe.

A variation of the slip joint is used where a third or fourth leg is necessary, as in a sofa. This is also used where a table



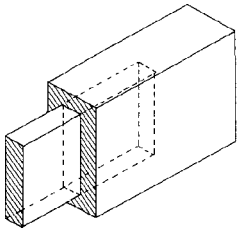
apron is joined to the legs if the table apron is bricklayed round or oval as in a Hepplewhite table.

There are several ways to make a mitered mortise and tenon. Often a spline is used, as it is easier to cut. Sometimes



a spline is used purely for visual effect. The spline can also be hidden.

If a tenon should break, a spline can be inserted. The same method is often substituted for a mortise and tenon.

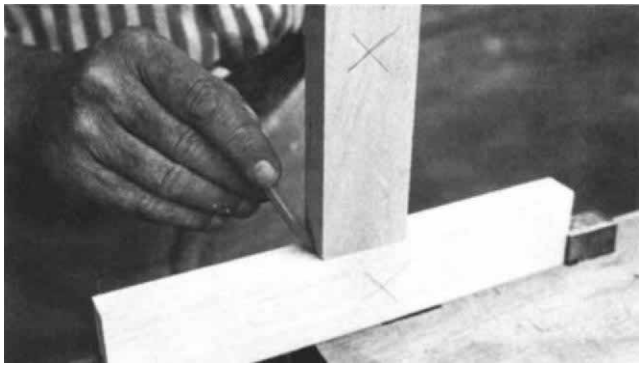


Although it is not as strong, the spline is in most cases sufficient, and is again much easier to make.

There are many other variations of the mortise and tenon joint but virtually all depend on the cheek and shoulder action for their strength. Similarly, the technique used in making these joints is basically the same.

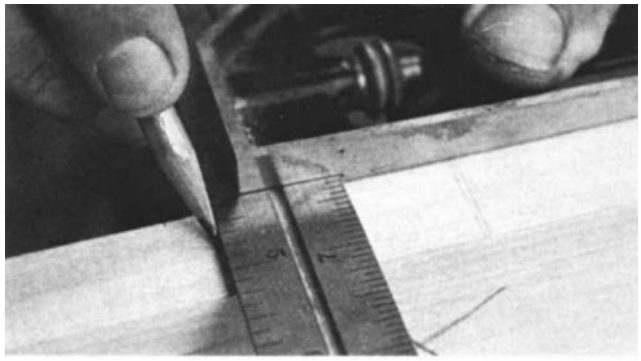
In making mortise and tenon joints, I find it easier and quicker to use hand tools, unless there are so many joints that power tools turn out to be quicker. But this is rarely the case because power tools — whether I'm using a saw, or a router or a drill press with a mortising bit — do take time to set up for the particular job. But even if you plan to use power tools, it's best to learn to do them by hand, so that you understand what you're trying to do with the power tools.

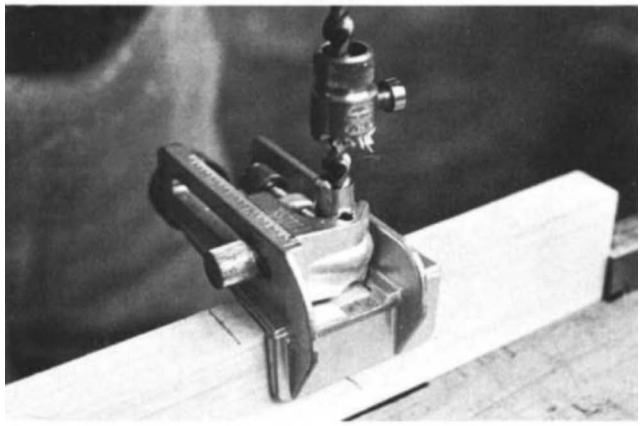
The first step in making the basic two-shoulder joint is to mark both pieces to keep the orientation right. Then I outline

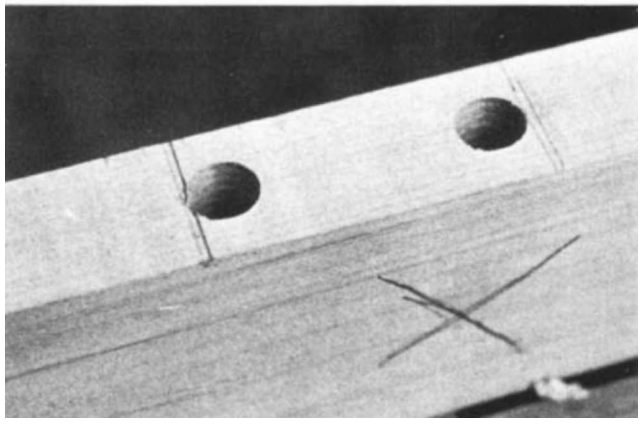


the tenon piece on the mortise piece, but I use a square to put lines just inside (less than 1/16-inch) those marks, because the mortise should be made slightly smaller to allow for subsequent sanding of the tenon.

I pick a drill or bit about 1/3 the thickness of the tenon board. If this size is between bit sizes, I use the next larger one. Although it isn't absolutely necessary, I recommend using a doweling jig to guide your bit while boring the mortise. You'll end up with straight and even sides. Make the

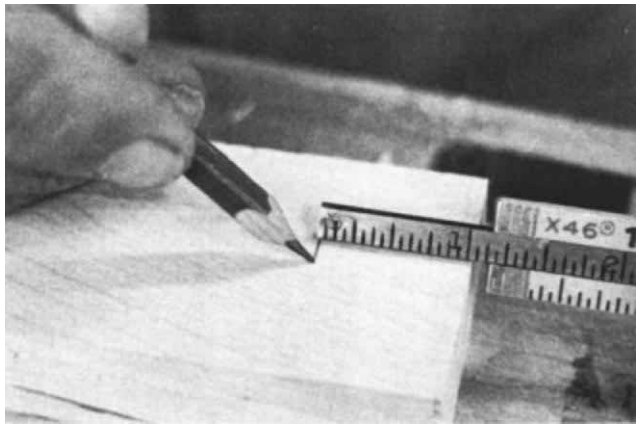




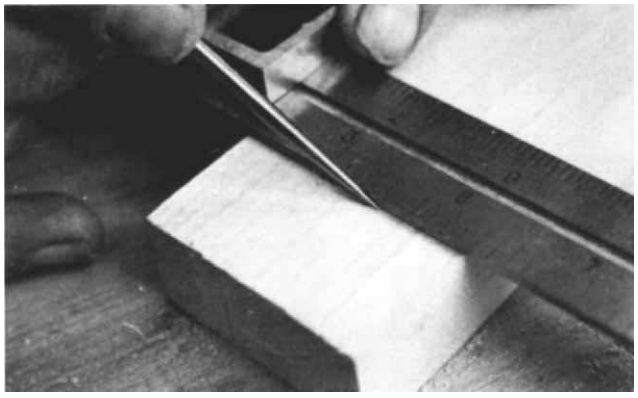


two outside holes first, then the holes in between.

Stop work on the mortise at this point and transfer its dimensions to the tenon board. First measure the depth of the mortise with a rule and make the tenon 1/8-inch shorter

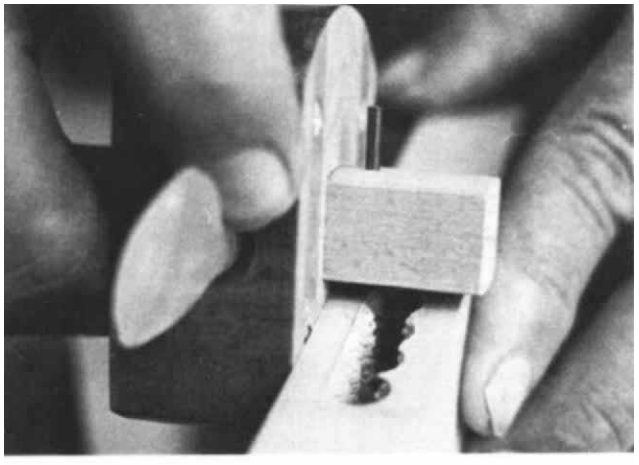


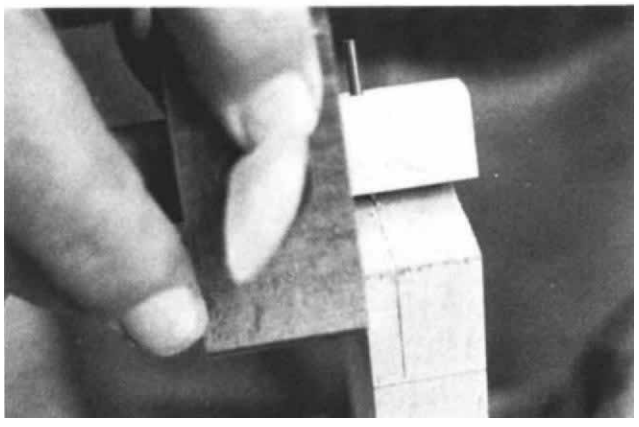
to allow for excess glue. I use a square and a scribe to draw this depth line around all four sides of the tenon board. This marks where the shoulders will go. Don't use a pencil be-



cause its line is too wide and the shoulder must be cut with great accuracy.

Then take a marking gauge and adjust it so its point just touches the nearer side of the holes bored for the mortise. Transfer this measurement to the ends and two sides of the

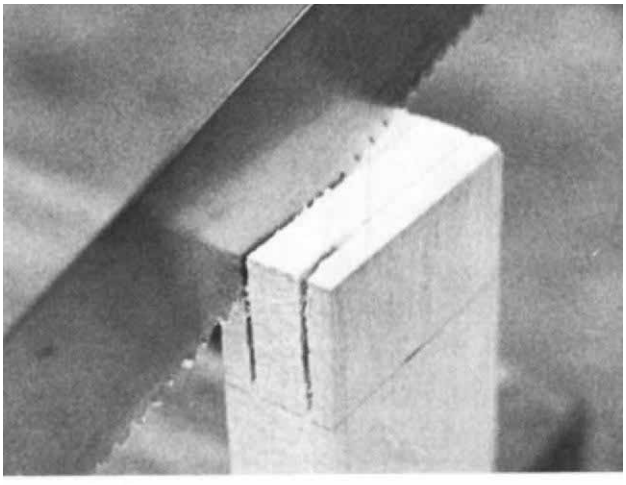


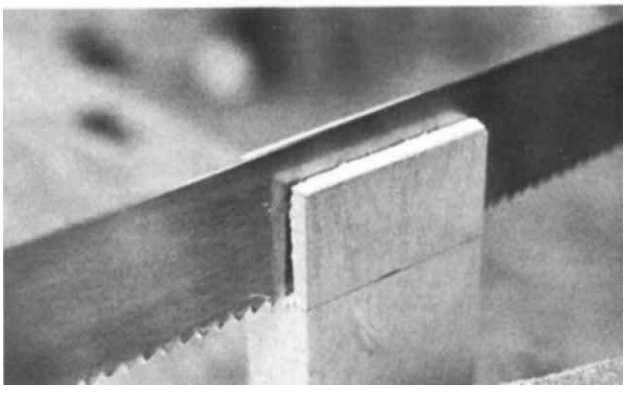


tenon. Then do the same for the other side of the mortise (but continue using the same reference surfaces).

You are now ready to cut the cheeks of the tenon. I use a frame saw for this (as I use for almost all hand sawing because it's the fastest and best saw there is) but if you don't have one, use a dovetail or back saw. The thinner the blade, the easier it will be to make accurate cuts.

The trick to cutting accurate cheeks is to cut the back line and part of the top first; then turn the board around and cut the rest of the top and the front lines. That way you don't have to worry about following two lines at once. When cutting the front line, the saw blade will be automatically

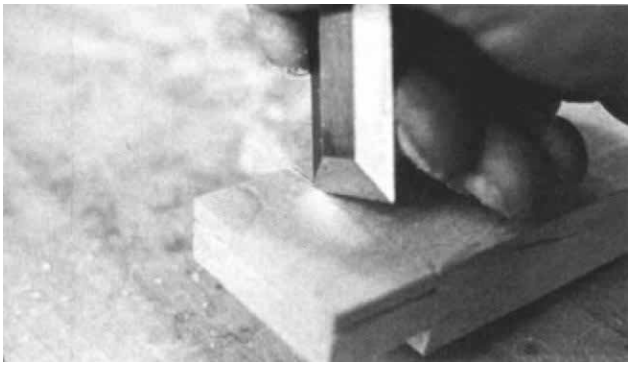




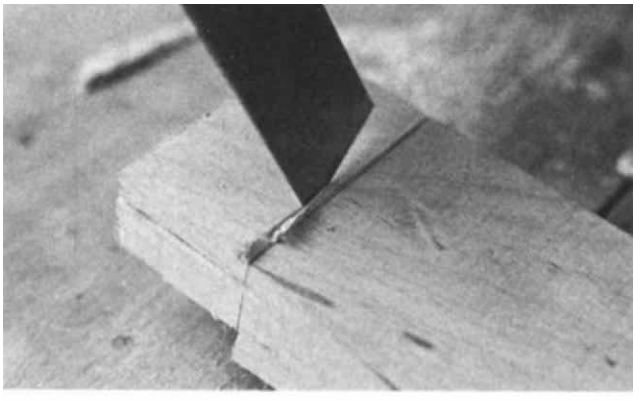
guided at the back by the kerf you made before. You'll also get a little more accuracy in this guiding process if you use a slightly thinner blade for cutting the back lines than you do for cutting the front.

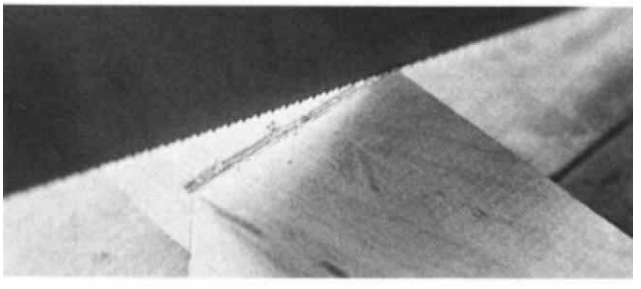
In any event, when sawing the cheeks, "split" the line on the waste side. The tenon cheeks must fit just right. If they're too tight they may split the mortise piece; if too loose, the glue joint may come apart under strain. Furthermore, the surface over a mortise that holds a loose tenon will in time become concave as the wood dries.

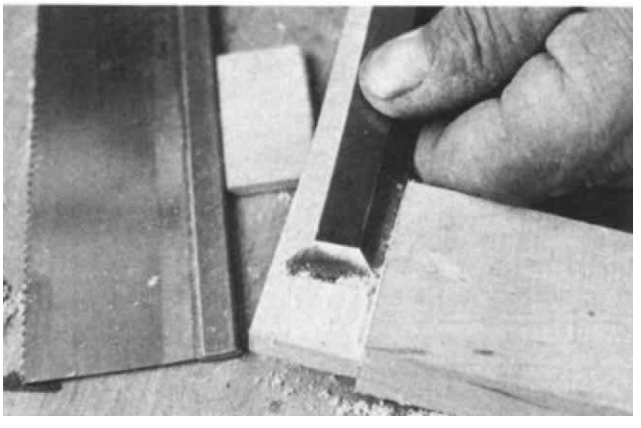
After the cheeks are sawed, it's time to saw the shoulders. One trick I've found helpful to improve the accuracy (since the shoulders must be perfectly aligned) is to make in effect a small or mini-shoulder for the saw to lean against. Take one corner of a flat chisel and deepen the shoulder line by



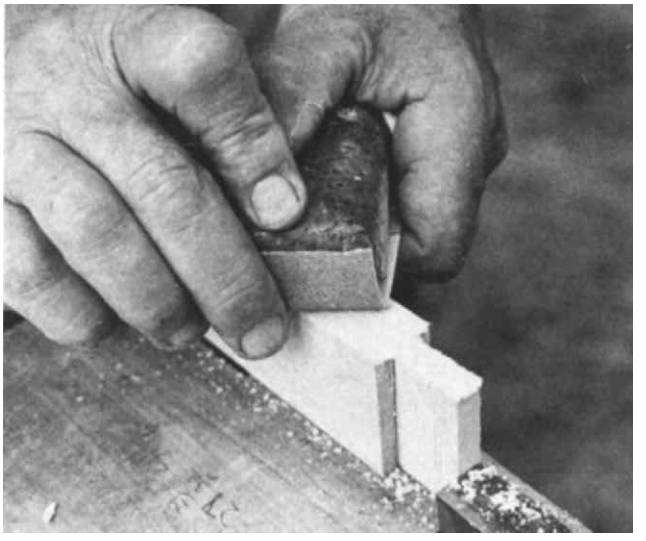
drawing the chisel along it. Then take a second cut at an angle to create half a "vee". You can then use this notch as a guide for your dovetail or frame saw. Finish sawing the shoulders and use a flat chisel to clean up the cheeks, and then round



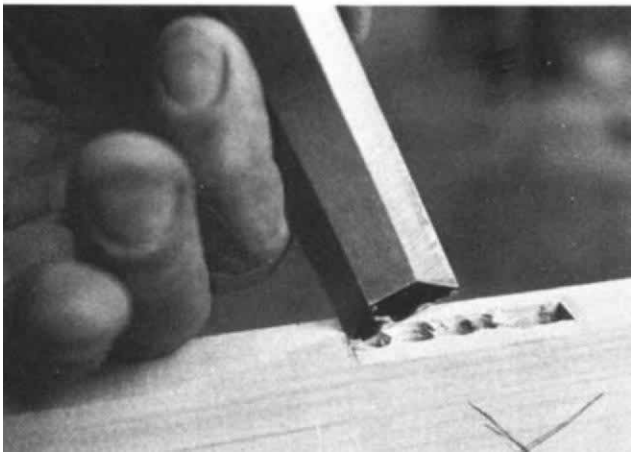




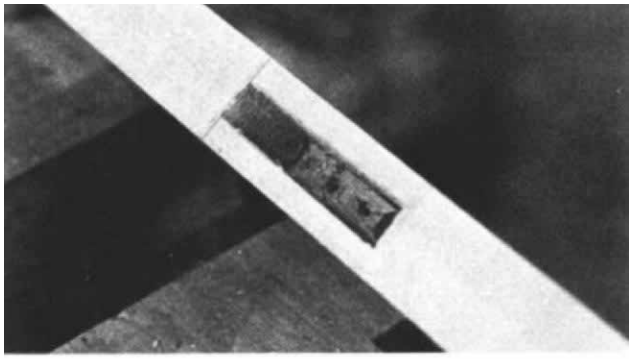
off the tenon corners slightly for easy insertion. Then sand the edge of the tenon so it will fit into the slightly shorter mortise.



Now finish making your mortise. Take a small chisel and mallet to square off the corners, and a wide chisel (but no mallet) to flatten out the sides. Sand the outside edge of the

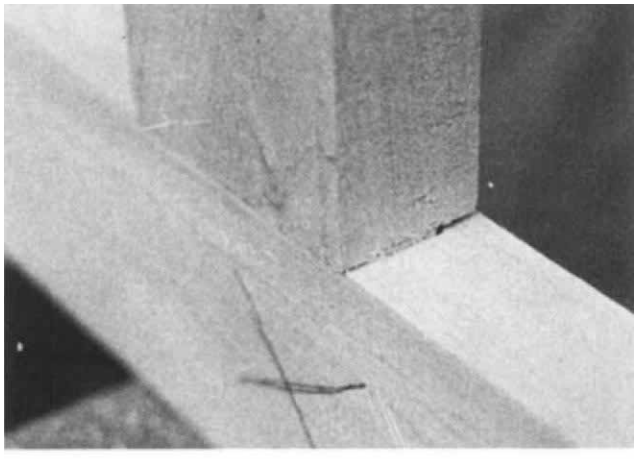


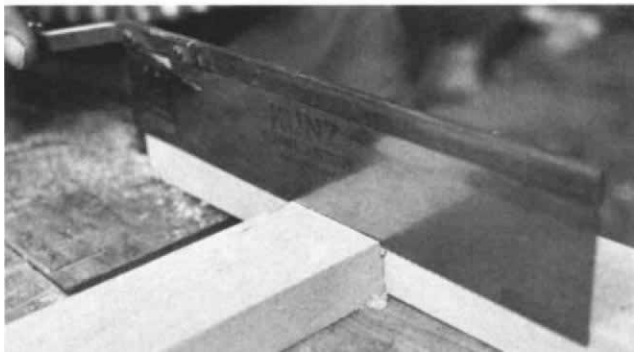
mortise piece as you did the tenon sides and you're ready to try the fit. You should be able to push it in by hand with the weight of your body. If you need to hammer it in, it's too tight and you should shave some material off the tenon



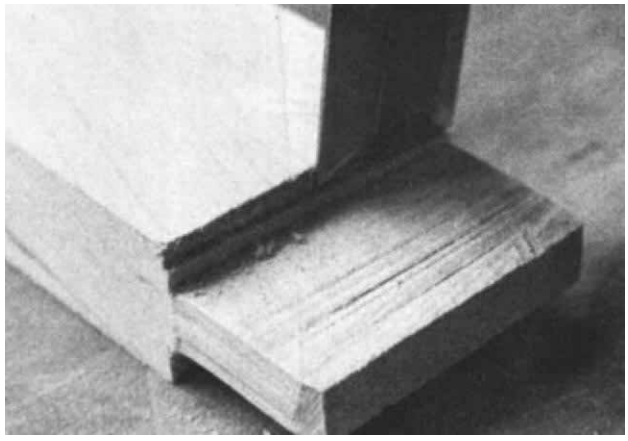
cheeks because that's the easier piece to correct. If the tenon is too loose, you can glue strips of veneer to the cheeks.

If after fitting, the shoulders are slightly off as illustrated here, there's a trick you can use to align them. With the joint

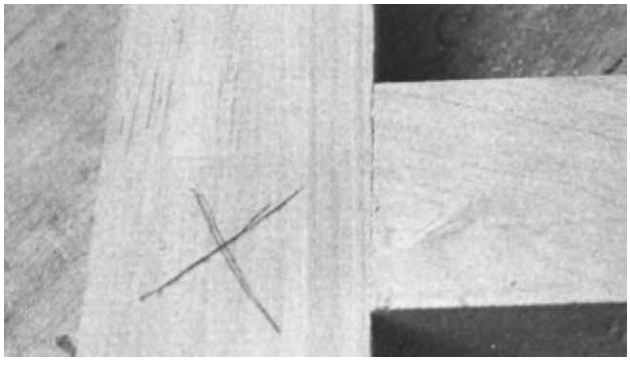




assembled, make a clean saw cut along the shoulder line, making sure not to cut into the mortised piece at all. Do the same for the other shoulder. Don't saw quite completely to the tenon. Instead, finish the cuts with a chisel after the joint is disassembled. If you're making a frame and notice one of



the shoulders is off after you've dry clamped it, make the shoulder correction cuts to all the shoulders on the same side of the frame, so that after correction, the frame stays square (but one blade width shorter). Of course, if a shoulder is really off, you may need to go through the correction process twice.



On complicated pieces where the joints may come in at odd angles, I sometimes don't worry about precise fitting of the shoulders during the initial cutting process, but rely instead on the correction cuts to get the fit I want.

When gluing a mortise and tenon joint, it is very important to put a moderate amount of glue in the mouth of the mortise, and just a little on the beginning of the tenon cheeks and on the shoulders (as insurance).

There should not be so much glue that the glue runs out over the work and the bench and all over the craftsman. Anyway, a tight joint does not allow room for too much glue.

When gluing up a table or chair it is much better to glue up two opposite sections first and later glue them together. If everything is glued up at once, too many clamps are used, and it is more difficult to square the whole piece up at once.

Regardless of the variation of mortise and tenon joint you are making, or whether you are using power tools, the construction process is the same. Make the mortise first and transfer it's dimensions to the tenon piece. But don't try to make the mortise and tenon independently.