

First Draft 9/1/07

Second Draft – in process 9/28/2007

Copyright, 2007, Woodworking for the Blind Inc.

## Four-Squaring Wood

### Chapter 2, Section 1:

The starting point for any project is using wood that is flat and square. Precise alignment and fitting of parts for any project is possible only if you begin with wood that is flat and square. Very often, the woodworker has to mill the wood and remove defects in order to make the wood flat and square.

Wood from the sawmill or lumberyard comes in a variety of conditions. Often wood is rough sawn on all four sides or if the faces are relatively flat, there may be a waney edge, that is, an edge that still has remnants of the tree's bark. At many

lumberyards, wood may be smooth sawn on two faces and is known as S2S wood or “surfaced two sides.” Home centers usually offer lumber that has been surfaced on all four sides, known as S4S, “surfaced four sides” or also known as dimensioned lumber, meaning lumber that has been cut to uniform nominal sizes such as one by fours, two by fours, one by sixes, etc. But don’t be misled. These sizes are only nominal, that is, in name only since the actual sizes are much smaller, usually by one-quarter inch in thickness and by one-half inch in width. For example, a one by four is actually three-quarters inch thick by three and one-half inches wide; a one by six is three-quarters inch thick by five and one-half inches wide and construction two by fours frequently are only one and a half inches thick by three and a half inches wide. Lengths, on the other hand, usually are exact.

Whether lumber is rough faced, surfaced on two sides or surfaced on all four sides, the wood may come with other defects. Individual planks can be cupped, bowed, crooked or twisted. Other defects include end checks, shakes, surface checks, honeycomb checks or the wood may contain ingrown bark or dead or encased knots. The various defects may be natural conditions or may have been caused by improper or insufficient drying. Whatever the case, the defects usually have to be removed before the wood is ready for a project. The exception, of course, would be character flaws such as knots or much more rarely, perhaps even long cracks that are to become part of the design or character of the project.

The Basic Milling Process. The objective is first to make or joint one face flat so it can become the reference face for the rest of the process. Secondly, you will plane the opposite face flat and parallel to the first face. Thirdly, you will make

or joint the adjacent edge flat and square to the first flat face and this will become the reference edge. Finally, you will rip the opposite edge flat and parallel to the first edge. By making the second face and second edge parallel to the reference face and edge, you also make them square to their adjacent sides. Finally, you will cut one end square, then measure and cut the opposite end square and to length. The foregoing method follows the acronym F-E-E standing for faces, edges, ends in that order.

Alternatively, woodworking manuals and articles often describe the process as first joint one face, then joint one edge, followed by planing the opposite parallel and finally ripping the opposite edge parallel. Either process works.

Four squaring a board can be accomplished with either power machine tools or hand tools. It is quicker, easier and

more accurate to use machines as most woodworkers do but also noisier and dustier.

First, let the wood acclimate. Milling workpieces flat comes at the beginning of a project and should be the essential first step. Wood for any project should be acclimated to your shop at least a week or two before using it. If there's any chance that the wood is not thoroughly dry or if your shop is either particularly humid or particularly dry, wait a few more weeks at least. The wood will move during this time as it equalizes with the moisture in your shop. As it moves it may warp but it is better to discover that before beginning the project than while a piece of furniture is half-built and parts refuse to fit.

During this time you can inspect the wood for defects and plan around them. Mark all unwanted defects such as knots, splits, gouges, etc. Mark long boards into smaller pieces

according to your particular needs. Cut long boards into approximate lengths. It is much easier to mill these shorter lengths than handling long boards. Many woodworkers advise leaving boards 2 to 4 inches longer in length to allow for later cutting off planer snipe or other defects in the ends of the boards. I usually leave the boards about an inch long although often enough I wish I had left them longer to handle some problem or mistake that came up. Next, rip the board to approximate width. If the board is rough sawn it's important to keep it oversize since you may have to trim away warp a couple of different times before the board stabilizes and finally is milled flat and square.

Four-squaring a board with machines involves the use of the jointer, thickness planer and tablesaw. Details on the use of these machines and jigs and accessories to ease the use of these machines will be covered in later chapters. For now we'll simply discuss the four-squaring process itself.

## Chapter 2, Section 2:

Jointing a Board's Face. When the board has acclimated to your shop, you're ready to begin the milling process. First, let's assume the board is relatively flat without any warp. Later on we'll discuss how to handle the four types of warp. Start the four-squaring process at the jointer. The jointer should be set for a light cut of no more than one-thirty-second inch. You're cutting across the full width of the board and you don't want to lug down the motor. Orient the board on the infeed table so that the edge grain is falling away from the cutterhead. This is important to avoid tear-out. The edge grain should run from the upper edge of the board down towards the trailing end on the bottom edge of the board. For tightly grained or irregularly grained woods likely you will have to rely on trial and error to determine which way to orient the board. Joint the board one direction and if that direction produces a smooth cut, continue to joint in that

direction. If the cut produces tear-out, reverse the direction and see if that is better.

Telling Grain Direction by Feel. Sometimes grain direction can be felt by running your fingers down the length of the face of the board. One direction will feel smooth to the touch but the opposite direction will feel a slight roughness. This roughness is going against the grain while the smooth feeling is with the grain much like stroking a cat's fur with or against the grain. The face should be placed down flat on the jointer bed with the smooth direction running down towards the trailing end of the board. Telling grain direction by feel will not be possible with all boards. Of the more common domestic woods, you have a better chance of feeling the grain direction with open-pored woods such as white oak, red oak and sometimes poplar, but usually not with more closed-pored woods such as walnut, cherry and maple.

Bob Kennedy uses his fingernail to check for grain direction since his hands have become so toughened from years of use and his sense of touch no longer feels sensitively.

Jointing the First Face. Joint one face only using push blocks to move the board and to protect your fingers. Use a flat bottomed push pad with a cushioned underside in your left hand to lightly hold the board flat and steady as it passes over the cutterhead. Do not push down hard because that possibly will flex the board. In your right hand use a push block with an overhanging lip or wooden hook at the end of the block to grip and push the board over the jointer bed. Be careful not to apply too much downward pressure with this block on the end of the board since the pressure will lift up the opposite end of the board and not allow it to be jointed properly. If the board is long, begin by merely resting the lipped push block on the upper face of the board and push

the board with your hand until the end approaches the beginning edge of the infeed table of the jointer bed. By this time more of the board will be beyond the cutterhead and onto the outfeed table thus providing some counterbalance. You can then pick up the push block, position it at the trailing end of the board and continue pushing the board safely over the cutterhead. Do not hesitate too long before continuing to push the board or you will risk the cutterhead gouging a line across the width of the board as it sits motionless over the cutterhead.

You may want to make two or three passes across the jointer to ensure that the face of the board is jointed absolutely flat.

Feed Rate. You want to pass the board over the knives smoothly with a slow and even feed rate. If you feed too rapidly, the jointer will leave a series of spaced ripples on the

face of the board. If you feed too slowly, you risk possibly burning the face and unduly dulling the knives. If you stop feeding you risk the cutterhead gouging a curved recess across the face of the board. So work on developing a smooth, slow and even feed rate.

Jointer Machine Marks. Even with a proper feed rate, the jointer may leave a series of finely spaced minute ripples across the face of the board, particularly if the knives are dull. These ripples can be removed with a hand plane or can be sanded off with 120 grit sandpaper as you prepare the board for finishing. In fact, it's always a good idea to take a couple of very fine shavings with a hand plane or cabinet scraper to remove machine marks and avoid the need for heavy sanding.

Thickness plane the opposite face. Now, with one face jointed, it becomes the reference face and you're ready to

move to the thickness planer to plane the opposite face exactly parallel to the jointed face. Set the planer for a light cut. Place the jointed face down onto the bed of the planer. To avoid tear-out, it's important to orient the board so that the grain direction rises toward the overhead cutters and towards the trailing end of the board. The best way to remember proper grain orientation is to position the board with its jointed face down and with the leading end from the jointer now becoming the trailing end in the planer.

To minimize warping, be sure that you take off the same amount of wood from both faces. If you passed the board over the jointer knives three times, do the same for the planer.

Planing the Board Thinner. If the board is thicker than you want, say the board is three-quarters inch thick and you want a board only five-eighths inch thick, use the thickness planer

to bring the board to the desired thickness dimension. But in doing so, be sure to take off the same amount from both sides. To maintain proper grain orientation and to avoid tear-out, after planing one side, flip the board over end for end and repeat this after every pass. This will keep the grain properly oriented.

Dealing with Irregular or Swirly Grain. When a board has straight grain, the thickness planer does a beautiful job of leaving a smooth even surface that might almost feel silky. But the thickness planer turns mean when faced with difficult grain leaving a pocked surface of tearout. If you have irregular, swirly, wavy or tight grain on the face of the board, dampen the face of the board to be planed with a wet rag to soften the fibers, wipe off any excess moisture, and then feed the board at a slight angle to minimize tear-out.

Thickness Planer Machine Marks. The thickness planer may leave a series of finely spaced minute ripples, particularly if the knives are dull. These ripples can be removed with a hand plane or sanded with 120 grit sandpaper. It's always a good idea to take a couple of very fine shavings with a hand plane or card scraper to remove machine marks and avoid the need for heavy sanding.

Thickening With a Drum Sander. An alternative to the thickness planer is the drum sander. This machine has a large heavy horizontal drum wrapped with sandpaper, a smooth level bed and rollers to move the workpiece through the sander. The drum sander is a much slower alternative since it is difficult to take off much over one-thirty-second of an inch with each pass. Passes usually are made in one-sixty-fourth inch increments. But the drum sander is an excellent alternative for thickening wood with irregular grain since there is absolutely no tear-out.

Joint the first edge. Once both faces are flat and parallel, place the reference face against the fence of the jointer and proceed to joint one edge of the board. The jointer fence must be set at exactly 90 degrees in order to get a square edge. It is important to keep the reference face tightly against the fence so that the edge will be jointed square to the face. Once again, be sure to orient the grain of the board properly to avoid tear-out. The grain should run from the top edge of the board diagonally down towards the trailing end of the board. Unfortunately this grain direction usually cannot be felt.

It's also important to press down lightly but firmly on the board so that it stays level on the infeed table and in contact with the cutterhead as the board passes over the knives. If the board is wide enough, say at least three or four inches wide, you won't need push sticks but can use your hands to

keep the board in position. With a wide board, your fingers will be well away from the cutterhead. Press down lightly and press firmly against the fence to be sure that you get a square edge. Place the fingers of your left hand on the top edge of the board and the thumb of your left hand against the upper side of the back face of the board to hold it firmly against the fence. Bob Kennedy says that he has big hands and as a safety reference he drapes the fingers of his left hand over the top of the fence, uses his thumb to keep the board against the fence and then uses his right hand to do all the feeding. Alternatively, put your left thumb on top of the board and cup your fingers against the face of the board. Use the fingers and thumb of your right hand to grip the top edge and end of the board in order to move the board forward. If the board is narrow, say less than three or four inches wide, then you will need a push stick to hold the board in position. Don't let your fingers get near the spinning

knives and don't let your right hand fingers slip down off of the back end of the board. I speak from experience!

Adjusting Jointer Depth of Cut. Like many woodworkers, I keep the jointer knives set to take a very, very thin cut even when jointing an edge, but if the edge is narrow, you could increase the depth of cut to about one-sixteenth inch. I do this only if the edge is irregular or wavy and a substantial amount of material must be removed to get it straight. A somewhat deeper cut reduces the number of times the edge has to be run over the jointer to get it straight, but It also makes for a slightly rougher cut. Listen to the machine as you move the edge over the cutterhead. You will hear a definite working sound when the jointer is cutting but you will hear a much smoother sound when the jointer is not cutting the edge. This means that the edge is not in contact with the cutterhead, usually because there is a small crook or curve along the edge but it also may mean that you have

mistakenly pushed the end of the board down tilting the edge up off of the cutterhead. Repeat the cut until you hear a working sound continuously along the full length of the edge. Armando Del Gobbo uses an awl to lightly scratch the edge of the board every three or four inches. When the scratch marks are shaved off by the jointer he knows the board's edge is flat.

Jointer Machine Marks. The jointer may leave a series of finely spaced minute ripples along the edge, particularly if the knives are dull. These ripples can be removed easily with a hand plane, disk sander or palm sander.

Router Can Edge-Joint a Board. With the router set up with a flush trim bit and mounted in a router table, edges of boards can be jointed flat.

Rip the second edge. You now have both faces flat and parallel to each other and square to one flat edge. To make the second edge parallel to the first, take the board to the table saw, position the jointed edge against the fence and rip the opposite edge. Use a featherboard to hold the board tight against the rip fence and use a push stick to move the board forward and through the blade.

Machine marks. Once again, a hand plane can be used to remove sawblade machine marks from the cut edge or the marks can be sanded away.

Result. Your board is now milled four square so that each face is flat and square to the adjoining face. Repeat this process for all of your pieces. This may be tedious but it is essential for quality work. The process works best when all pieces go through the same step one after another before adjusting the planer for the next cut. That way you can be

sure that all pieces come out with exactly the same thickness.

### Chapter 2, Section 3:

Warped boards. Now let's look at what to do if your boards are not flat but are warped. Boards can be warped in four different ways. The board can cup which is a curve across the face width of the board. It can bow which is a curve along the face length of the board. It can crook which is a curve along the long edge of a board. And it can twist or wind which is a slight spiral along its length resulting in two corners being higher and two corners being lower so that the board rocks when placed on a flat surface.

Test the flatness of boards by laying them on a flat surface.

The table of the tablesaw is about the most reliably flat surface in your workshop but it won't accommodate longer boards. For longer boards, try your kitchen countertops.

While they may not be perfectly flat, they will let you determine the relative flatness of most boards. For cup, feel along the end of the board to determine if the end lies flat or if there is a gap either in the middle of the end or at the edges. For bow, feel along the length of the board to determine if there is a gap between the countertop and the ends or if there is a gap in the middle of the length. For crook, stand the board on each long edge and determine if there are any gaps. For twist, lay the board on the countertop and see if the board rocks from side to side.

None of these conditions is acceptable. Generally, warping is more pronounced in larger boards and more difficult to correct. If possible cut down the size of the boards to simplify milling. A long bowed or twisted board, for instance, will be unacceptable for use in a long tabletop but shorter lengths of the same board probably can be milled flat. The difficulty of

correction depends on the amount of warp, the thickness of the board and the length of your jointer bed.

Two steps may be called for. First you do rough milling to remove the serious problems without concentrating much on square edges and then waiting a few days to let the wood re-acclimate again. Only then should you begin the second step of final or finish milling to prepare the wood flat and square for use in your project. Set the jointer for a light cut even for rough milling. It's easier to avoid mistakes such as taking off too much material resulting in a board that is tapered along its length and light cuts are easier both on you and your machine.

Bowed boards. Bow is a curve or broad bend along the face length of a board. Your objective is to remove enough material from the ends of the board so that it eventually lies flat on its bottom face. This means that after jointing the

reference face flat, the ends will be thinner than the middle section. The discrepancy will be corrected in the thickness planer when you take the second step of making the opposite face parallel to the reference face.

If possible, cut the bowed board into shorter lengths before beginning to flatten the bow. This will reduce the amount of wood that must be removed to correct the bow.

Place the bowed board with the concave or bowed face down on the jointer bed. Your objective is to gradually slice off the high points of the bow at the ends of the board. This is relatively easy to do if the board is fairly short and generally fits on the jointer bed but much more difficult to do if the board overhangs the infeed table by any distance. If the board generally fits the table, proceed by pushing the bowed face of the board over the cutterhead. Do not press down on the middle section of the board flexing it to lie flat

on the jointer. Use a light touch so that the cutterhead cuts only the leading end of the board and the trailing end of the board but not cutting the bowed up middle section. Continue to make passes in this manner. As more passes are made, the raised middle portion will get closer and closer to the cutterhead, eventually being cut as well. Now take a final pass or two and the result will be a flat, jointed face.

If the bowed board overhangs the infeed table by very much, then the high trailing end of board will not lift up the middle portion of the board until the trailing end reaches the infeed table resulting in an unwanted cut into the middle portion of the length. To avoid this, push the leading end of the board over the cutterhead for a short distance, then stop and lift the board off of the cutterhead. Keep your hands well away from the spinning cutterhead. Return to the starting position and repeat the cut. After a few passes, much of the high spot will be removed from the leading end. Now reverse the board

being sure to keep the bowed side down. Repeat the process by now pushing the opposite end of the board over the cutterhead for about the same number of cuts. Check to see how much bow remains. If a lot of bow remains, repeat the process all over again. If only a little bow remains, you can then proceed with passing the entire length of the board over the cutterhead until the bottom face is flat. After a number of passes the jointer will be cutting along more of the length of the board. Do not press down on the board to flatten it across the cutterhead because you will be cutting into this portion of the board prematurely. Continue to feed the board to remove the high spots near the corners. Eventually the entire face of the board will become flat.

Severely bowed boards may hit the front edge of the outfeed table immediately after the board passes over the cutterhead. This requires you to manually lift the board to place it on the outfeed table and continue the cut. This step

may have to be repeated a few times before enough of the high spots have been removed to permit the board to slide onto the outfeed table. You could also turn the board 180-degrees with the same face down and begin cutting the high spots off of the other end. After a few passes the board should no longer catch on the outfeed table.

The process of cutting off the high spots on the ends of the boards will result in the ends of the board becoming thinner while the middle portion of the length remains thicker. That's OK for now because the objective is to get only one face of the board completely flat. Later on, the thickness planer will remove the thicker midsection. Once the jointer seems to be cutting along the entire length of the board, make a final pass or two to ensure that the face is flat.

Depending on the amount of the bow and the length of the board, there could be a substantial reduction in the thickness

of the board. That's the reason why bowed boards are best treated in shorter lengths. Now take the board to the thickness planer and make the opposite face flat and parallel to the jointed face.

Cupped boards. Cup is a curve or bend across the width of a board. If possible, rip the board into narrower widths to ease correcting the problem. Place the concave surface of the board face down and begin to joint the board. The cutterhead will gradually remove the high spots along the long edges of the board eventually resulting in a flat face. Rarely is the cup so severe as to cause problems with normal jointing. If the cup is severe, it's best to rip the board down the middle and then proceed to flatten each of the two narrower boards. Once both boards are flat, they can be edge-glued back together to produce a wider board. Once the face is jointed flat, move on to the planer.

Twisted boards. Twisted boards (also called wind) are the most difficult to correct. When confronted with a twisted board I do everything I can to avoid using it. Many twisted boards seem to be hopeless cases because they re-twist after having been jointed flat. If the board is only slightly twisted, that is twisted about one-eighth inch or less, try cutting it into shorter lengths and narrower widths and proceeding generally similar to flattening a bowed board. If the twist is greater than one-eighth inch, you can try to use shims to somewhat balance the board on the jointer infeed table as you joint the leading end and then turn the board in a horizontal 180-degrees and joint the other end. The shims may help in reducing the amount of rocking as you push the board over the cutterhead.

With a board marred by a lot of twist, you can spend a lot of time trying to joint the board with repeated passes across the jointer only to wind up with a board that is too thin at one end

to be of use. Once again, the better answer is to avoid using twisted boards.

Crooked Boards. There are two very different methods for straightening a crooked board depending on the amount of crook. If the crook is mild, then the board can be edge jointed with the concave side down on the jointer. Push the concave edge along the cutterhead until the edge of the board clears and is no longer in contact with the cutterhead. It may require a number of passes to remove the crook. It will then be necessary to turn the board clockwise end for end in a half-circle and then begin to joint the opposite end of the board to remove that portion of the crook. When the crook seems to have been removed, then joint the full length of the edge a few passes to be sure it is flat and straight. Then take the board to the tablesaw to rip the other edge parallel to the jointed edge.

If turning the board in a half circle to joint the opposite end causes tearout, then turn the board back to the original position and move the board forward until the crooked edge again comes in contact with the cutterhead. Repeat this step a number of times until the edge has been straightened.

The second method is to use the tablesaw for severely crooked boards. Crooked boards are a problem on a tablesaw because there is no flat edge surface to reference against the rip fence. Do not ever attempt to cut a crooked edge on the tablesaw by trying to guide one point of the curved edge against the fence. Instead, take a long piece of plywood to use as a base. The right hand long edge of the plywood will ride securely against the rip fence. Nail or screw each end of the crooked board to the plywood base so that the board's crooked edge overlaps the outer edge of the plywood. The plywood base will ride securely against the tablesaw rip fence and carry the crooked edge of the board

through the sawblade. Set the rip fence so that the blade will cut off the crooked edge of the board. Once the edge has been cut straight, remove the plywood base, turn the workpiece board horizontally 180-degrees so that the just cut edge is now against the tablesaw fence and cut the opposite edge to be sure it is exactly parallel.

Ready to move on. Don't short cut the foregoing steps.

They are essential to precision craftsmanship. Once your stock has been milled flat and square, you're ready to move on with your project. Store your individual parts on edge in a parts rack. This will help protect them against damage, will expose them to moisture change evenly and they will be readily available for use as you need them. Use the pieces as soon as you can. If you must store pieces for future use, be sure to sticker and stack the pieces on a dead flat surface. Make the stickers all the same dimensions at least three-quarters inch thick and arrange the stack so that all

stickers are lined up. It is also possible to store parts by wrapping them in plastic or in shrink wrap to help control moisture and wood movement.

#### Chapter 2, Section 4:

Four-squaring Using Hand Tools. Wood can be flattened and straightened with hand tools as well. The process is slower, quieter and a lot more work but it is certainly doable.

Because for most woodworkers, flattening with hand tools occurs only infrequently, only a summary of the hand tool process will be described.

First, choose the side to be flattened and orient the workpiece so that the grain rises in the direction of planing. If the board is cupped, plane the convex side because the board will lay flatter when resting on the raised edges.

Clamp the board in place either between bench dogs and a tail vise, or wedge the ends of the board between two thinner

pieces of wood clamped to the workbench. Use a scrub plane with the edge of the blade set to cut about one-sixteenth inch below the sole of the plane. Cut at a diagonal across the grain trying to plane the high spots while avoiding the low spots. This is very difficult. Plane diagonally across the entire board, then plane along the opposite diagonal. Check flatness with a straight edge and plane additional areas as necessary. The scrub plane will leave a slightly scooped surface along each line of cut.

Now switch to a bench plane and plane either diagonally or with the grain, whichever seems easier. Plane away all scooped areas, both ridges and valleys, until the board is flat. You will know the board is flat whenever you are able to plane long continuous curls of shavings from one end to the other. Check with the straight edge and feeler gauge to determine if the board is flat.

Now you must make the opposite face parallel to the first planed face so there is equal thickness throughout the board. Use a marking gauge to scribe a line at the necessary thickness around all edges and ends of the board. Clamp the board in place and use a scrub plane diagonally to plane off most of the excess thickness. Once the board becomes reasonably flat, switch to a bench plane and continue planing either diagonally or with the grain down to the scribed line. Note that it can be very difficult to feel this thin, shallow, scribed line and extremely difficult to know when you have planed the board exactly flush with the scribed line. (Mickey Fixsen, in fact, thinks its more trouble than it's worth especially since he has a jointer and wonderful thickness planer.)

To plane the first edge flat, make up a shooting board using a wide board as the base and a narrower board with an exactly flat jointed edge as a fence. Clamp the workpiece

between the base and fence with only the slightest bit of the workpiece's edge protruding beyond the edge of the fence. Use your longest plane, ideally a 24-inch jointer plane, with its iron set exactly parallel to the sole and square to the sides of the plane. Now lay the plane on its side on the base of the jig and begin to plane the edge of the workpiece. Plane until you are able to take one long continuous full width shaving from one end of the edge to the end. Next, use a saw to rip the other edge to finished width. Finally, use a saw to cut the ends square and to length.

The key to smoothing wood with edge tools is having very sharp blades. Wax the sole of the plane either with paste wax or with paraffin to reduce friction and make the plane slide more easily. Hand tools may seem like an awful lot of work and they are a real challenge for the novice. But with practice and very sharp blades, the novice soon gets the hang of it and the work seems a bit easier. Before long, the

woodworker no longer worries about how hard the job is going to be and notices it's quiet enough to hear the "whoosh" of the plane's blade neatly slicing away gossamer thin shavings. At that point the woodworker realizes the flattening job really can be done with hand tools and without overwhelming effort.