The mould is a piece of 18mm plywood cut to 50mm larger than the body shape. The hump in the centre starts 25mm inside the body outline and is shaped in a smooth curve flattening out on the top. This can be made from either 18mm plywood or 18mm MDF. The bridge position is around the middle of hump.The finished inside arch height won't be quite 18mm high because of the springback of the timber, but around a 15mm is usual.

Draw a centreline down the middle of the mould as this assists in lining up the soundboard halves when clamping. At the top of the mould, 10-15mm outside the body shape and 25mm each side of the centre line drill two 6mm holes halfway through the ply and make up two pins from 6mm dowel with pointed ends that stand around 25mm proud of the mould surface. These pins will locate the soundboard halves when clamping.

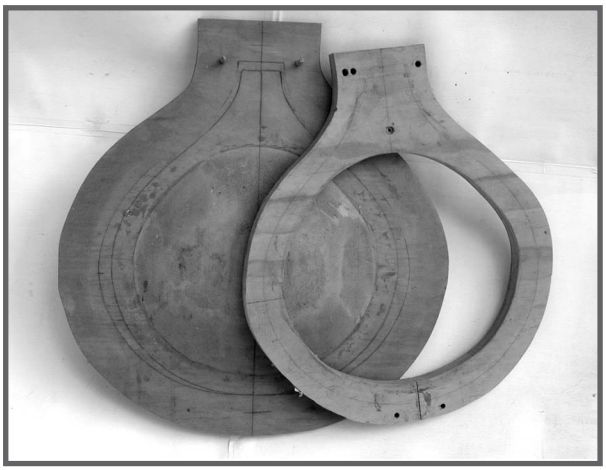
The clamping caul is also made from 18mm ply, and faced with cork. It is 40mm wide, half outside and half inside the body outline and this gives a little room on the inside before the spruce is forced into the curve. I used offcuts from cork floor tiles about 6mm thick for the facing. This lessens the chance of crushing the spruce, especially at the initial bend point into the arch. The caul should also have a centre line marked on it and have two 8mm holes drilled that line up with the holes drilled for the locating pins.

Another curved caul is useful to clamp over the length of the centre joint. This is made from a piece of 50mm x 50mm wood, a little shorter than the length of the hump, cut to the longitudinal curve of the hump and again faced with cork. This keeps the timber from 'lipping up' as it dries.

Moulding the soundboard

Relatively thick pieces of spruce, around 8mm thick are required. This is much thicker than soundboards usually supplied by most of the tone wood suppliers, so you may have to do a bit of phoning or emailing to find a timber miller who can cut these from a billet of spruce. Thickness the two pieces down to 7mm either with a hand plane, drum sander or thicknesser. Make sure that the inside surfaces are smooth, as when the two haves are moulded and glued together this will become the almost finished inside surface of the soundboard.

All the subsequent thicknessing will be done of the outside. Trim what will be the centre joint so that the grain runs as parallel as possible to what will be the jointed edges. Leave the spruce as rectangular pieces, as this makes gluing the two halves together easier later and drill two 10mm holes that line up with the two locating pins. These are made larger than the pins as the timber will shrink as it dries and move away from the centre line. A loose fit for these holes will preclude any chance of splitting around the holes. A couple of big pencil marks across the outside faces will assist in aligning the two halves at the clamping stage, and I write 'OUT' in big letters as well.



The mould and clamping caul

Soak both halves of the wood in water for at least 24-48 hours. If you have some way of getting them into continuously hot or boiling water this time would probably be reduced, but cold water seems to work fine. After soaking, seal each piece into oven bag material. Ordinary masking tape will seal the bags effectively enough, and the bags need to be fairly tight around the wood. Put the masking tape on what will be the outside surfaces. The bags should be well sealed so that the oven doesn't boil the moisture out of the wood, because it isn't nearly as flexible when that happens. Place the two bags in the oven on its lowest setting, usually about 150°C, and leave for about 20 minutes or until the bags have swollen up from the steam, and the wood feels flexible. Gloves are useful at this stage.

Have the mould, the caul and 8-10 big clamps ready on the bench next to the oven. (Some domestic negotiation may be necessary at this point!) Remove the two pieces of wood from the oven, still in their bags, and align them on the centre line of the mould so they butt together, making sure that the pencil marks on the outside surface of the boards also line up.

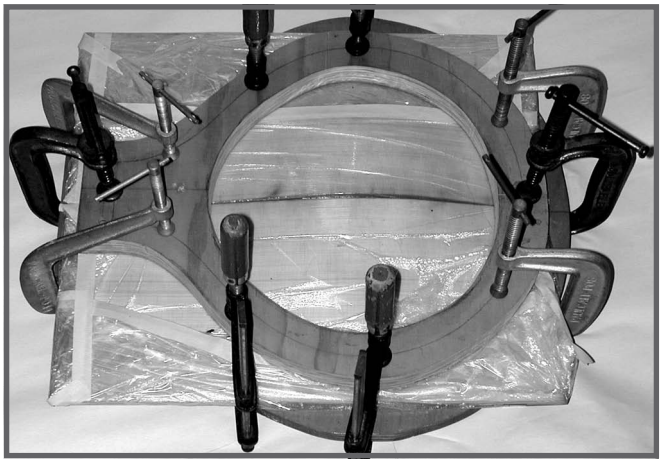
Punch the locating pins through the over bags. Place the caul on top and clamp at the neck end, and then another at the tailblock end and then place more clamps around the caul to clamp it firmly down to the mould all the way around. This all has to be done fairly quickly while the wood is still flexible from the heat.

Wait until the whole thing cools down and at this point cut away as much of the bags as is feasible without disturbing the caul and clamp on the secondary longitudinal caul. The next day it can be disassembled, the remnants of the bags removed and then reclamped until fully dry. Leave the whole thing to dry for at least four or five days in a warm spot. Don't try to dry it too quickly by placing it in the sun or over a heating vent. Let it dry slowly so that the tensions in the wood can relax. The spruce will shrink appreciably across its width, with a gap of 2-3mm at each end and more in the centre. When finally disassembled there always is some springback, but there should be close to 15mm of inside arch. If not soak and repeat.

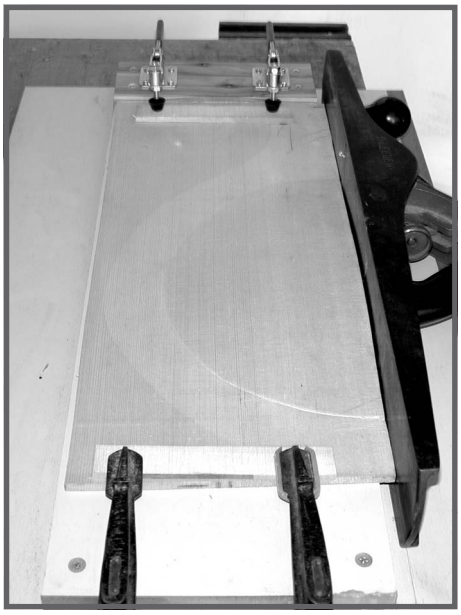
Joining the soundboard halves

Use a double sided shooting board and a long jack plane to joint the edges as this allows the plane to travel with the grain on both sides of the soundboard. Clamp the flat sections on each end down to the shooting board to make sure everything will be lined up at the gluing stage. A really straight cutting edge on the plane blade is important as different areas of the blade will be cutting the jointed edge because of the arch. More will have to taken off each end to get a straight joint because the arching process leaves a curved edge to the wood. Jim Williams' method of using of an aluminium level with sandpaper glued on one side is a good way if finishing off the joint if a long plane is not available. (see Jim's book *A Guitar Maker's Manual* - Hal Leonard Publications)

The traditional Spanish method of



Soundboard halves in the mould



Jointing one moulded half on the double-sided shooting board

50x25mm timber bars, rope and wedges is used to clamp the two halves together, but leaving the top bar off in the centre and using the centre wedge to just push the centre of the joint together if required. After gluing, roping and wedging make sure that the inside edges of the soundboard are as aligned as possible, pushing them into place as necessary.

Carving the soundboard

After letting the centre-joint dry overnight, cut out the shape of the soundboard leaving 1-2mm or so outside the body outline. The different between this method and the usual carving from a sold piece of timber is that in this case the inside arch is already established, and little should need to be done with it. The moisture from the moulding process will have raised the grain along the annular rings and this should be sanded smooth with 120 grit paper. Also smooth any discontinuity on the inside of the join and remove any glue squeezeout. At this point this soundboard had strong #5 mode resonance at C#.

The soundboard is graduated in much the same way as an archtop guitar or mandolin. The finished thickness will be 5.5mm or a little more in the centre down to 2.5-3mm in the channel 15mm in from the edge with the edge 4.5-5mm thick. The area above the soundhole should remain the same thickness as the edge, with the channel inside the edge disappearing each side of the soundhole.

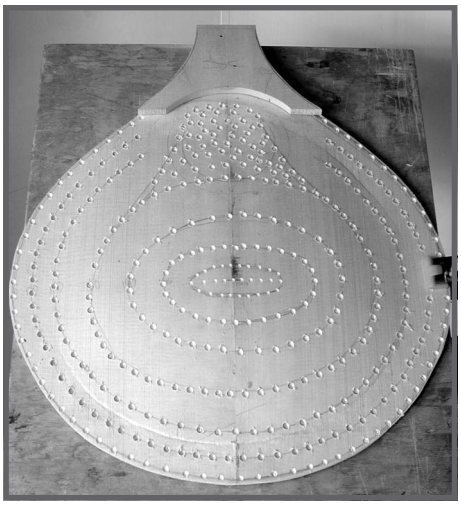
This graduating can be done quite quickly by depth drilling in concentric circles (turning a little egg-shaped towards the neck) to give thicknesses as appropriate points and then carving and planing away the excess. The initial drilling should be .5mm shallower than the finished thickness. Start by establishing the edge thickness by depth drilling and cleaning up with the small violin makers plane. Using a large gouge (I use 12 and 25mm No 8 sweep and a 18mm No 6 sweep gouge), cutting mostly across the grain, carve the wood away until the drilled holes almost disappear, and then using the two largest Ibex thumb planes, smooth off the gouge marks. Be careful about cutting into the grain runout.

Leave finishing the outside from the channel to the edge until after the top is glued to the sides so the concavity around the edges can be smooth up to the rim. In any case it is best to cut the channel with the 12mm No.8 gouge. Tap the soundboard again and measure the frequency. At this point the #5 mode frequency was a muddy C with a strong harmonic at F# an octave higher

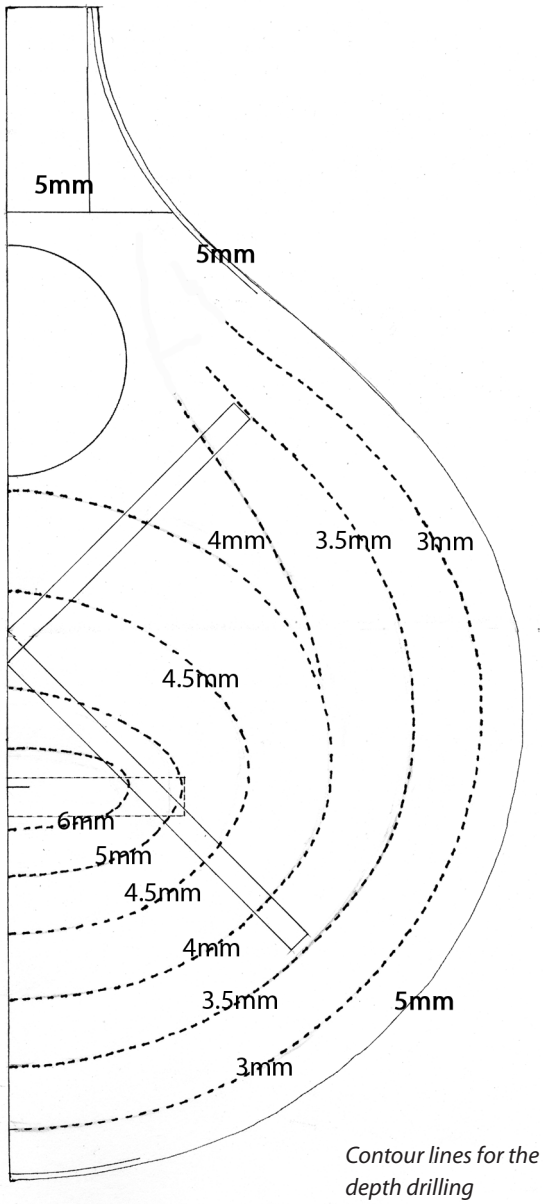
Using the dial calliper check the thicknesses, marking with a pencil the thickness every 25mm or so over the whole area of the soundboard. Adjust the thickness with gouges and the Ibex planes so the thickness decreases evenly from the centre to the channel. Some archtop and mandolin makers make the graduation more exponential than evenly distributed, with the soundboard thicker for a greater distance from the centre, and this might well work better for softer, lighter spruce.

Tap the soundboard holding it in the lower quarter of the soundboard to hear the #5 mode and check the frequency. The instrument built for this book had a #5 mode resonance at this point of B.

Gluing the moulded soundboard halves together

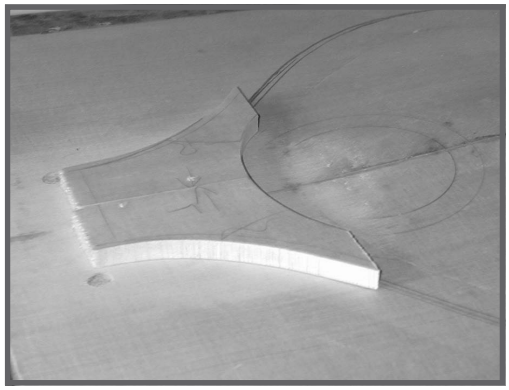


The initial depth drilling



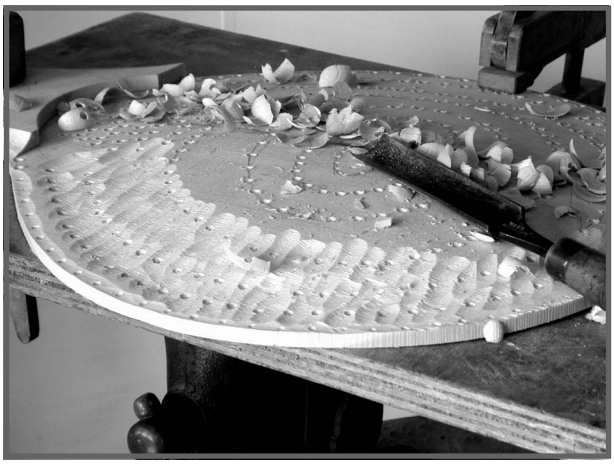
Contour lines for the initial depth drilling

An alternative to a constant 5mm thickness in the area above the soundhole, and the necessity then to fit a fretboard support in that area is laminating two pieces of soundboard offcut (preferably from immediately in front of that section of the soundboard) onto the main soundboard and carving that into a support for the overhanging fingerboard. If fitted carefully the laminated pieces will be virtually invisible after carving. The back edge, immediately in front of the soundhole is sanded to a matching curve to suit the outside diameter of the rosette. The rest of the soundboard can be thicknessed, but leaving the area around the fingerboard until the soundboard is attached to the sides. The angle for the top surface, which will support the fretboard will have to be worked out from a side view diagram. A straight edge along that surface should be 10mm (3/8") above the the bridge position

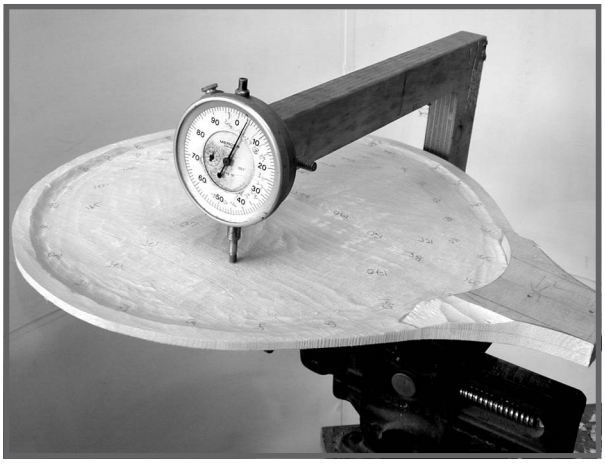


Laminating the fingerboard support. It is located with two small wooden pins - toothpicks or kebab skewers

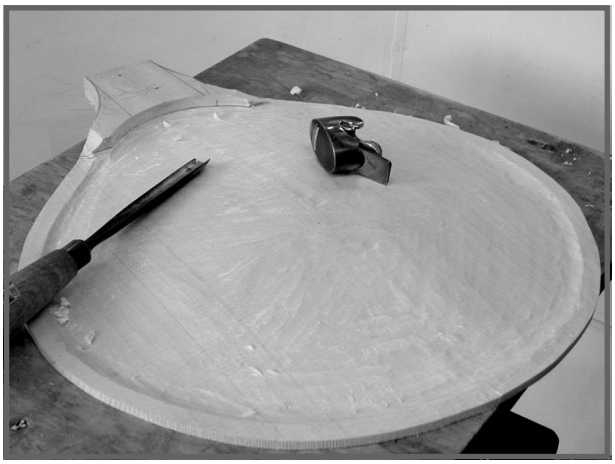
Planing the fingerboard/neck angle



Initial carving to the depth of the holes



Checking and marking the thickness with a dial caliper



Smoothing with a violin makers plane

The soundhole and rosette

As mentioned in the previous chapter, there are any number of ways that the soundhole rosette can be made. Classical guitars use a complex construction of mosaic tiles and veneer rings, while most steel string guitars use one or more concentric rings of various purflings. There is no reason not to have an oval soundhole, such as the style-4 Gibson mandolin family instruments, f-holes or more fanciful shapes, but I have only built bouzoukis and citterns with round soundholes.

My preferred style is a solid 10mm wide ring of either the same material as the body or the bindings, with the grain going across the soundboard, with the inside of the ring the edge of the soundhole, and purflings on the outside that match those around the soundboard. Feel free to be as inventive as you wish.

The neck edge of the soundhole should be 80mm from the end of the body. This allows 70mm for the heel-less neck mortice with another 10mm clear away from the soundhole edge. This also allows 22 frets clear of the soundhole while allowing the possibility of another 2 frets on a fingerboard extension.

Mark the centre of the soundhole another 40mm away and drill to suit the circle cutter's centre pin. A matching hole is cut in the rectangular workboard which will allow the circle cutter to rotate and be held securely.

A 110-120mm square piece of 2mm thick

timber for the rosette should be glued to a slightly larger piece of ply or MDF with a drop of glue in the centre. When dry drill a hole for the circle cutter and mount the circle cutter in the drill press on a slow (350 rpm or less) rotational speed. Cut out a circle with a 50mm outside radius and a 40mm inside radius. Cut the outside first and then move it inwards to cut the ring free.

Check the finished diameter of the rosette ring, and mark the inside diameter on the soundboard as well as the outside diameter, plus whatever purflings you want to use. Fit the circle cutter through the hole in the soundboard and the matching hole in the workboard and clamp the soundboard in place. Cut a circle on the inside mark around 2mm deep. Check that the ring just sits outside the inner cut and repeat for the outside circle cut.

Because of the arch in the soundboard it is trickier to cut than on a flat soundboard, but working away from the centreline gradually from top and bottom of the hole while adjusting the cutter in the slot will realise a smooth, even cut. A few more cuts between the two outside cuts will make chiselling out the waste to a constant depth of 2mm rather easier. Keep in mind the grain runout and be careful not to let the chisel slip and cut into the outside of the channel.

This a job which could be done with a small laminate trimming router or a Dremel in a jig which allowed the router to rise up and down indexed on a foot which remained outside the area to be removed, but I have never got around to making one.

Check the fit of the wood ring and the purflings. They want to be a press fit in to the channel. If the channel is too small use the cutter to slightly enlarge it. If it is too big you will have to rethink the purfling and possibly add a strip to fill the channel. Unclamp the soundboard from the workboard. Glue the rosette in place, with minimal glue to minimise squeezeout, using as many cam clamps as can fit with a piece of clingwrap to stop the clamps sticking to the rosette. The rosette has to be forced into the transverse arch of the soundboard.

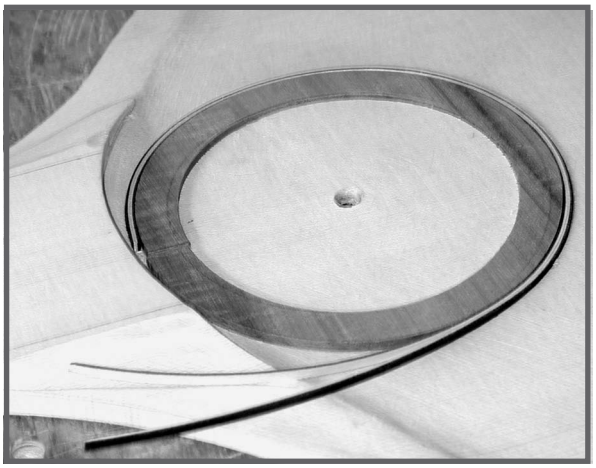
Leave to dry overnight and remove the excess of the rosette down to the level of the soundboard with a scraper and chisels, being careful not to cut into the surrounding spruce. Finish off with small sanding block.

With the soundboard clamped to the workboard again, cut out the soundhole with the circle cutter. Cut most of the way through from the outside and then turn the soundboard over and complete the cut from the inside.

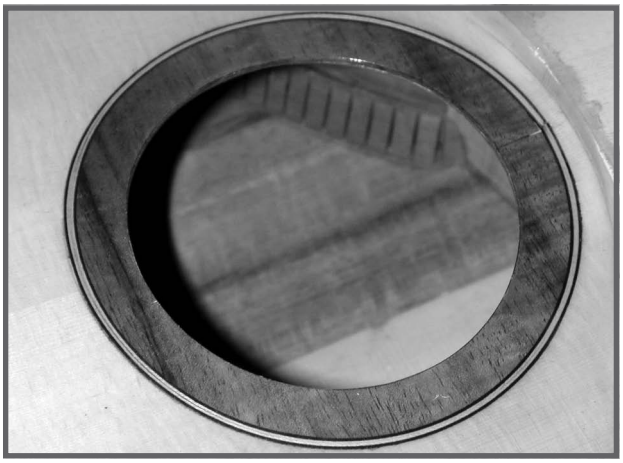
With 120 grit sandpaper slightly round over the inside of the soundhole and clean up any glue around the inside of the rosette.

Again tap the soundboard and note down the frequency or note that results. This one was between A# and B.

The soundboard X-brace



Fitting the purfling strips



The finished rosette

The bridge is 120mm wide, and each half of the X-brace needs to sit under the edges of the bridge. The upper ends of the braces should not come any closer than 10mm to the edge of the soundhole. Clamp the soundboard face down on the moulding caul with a cam clamp on each side and one each at the top and bottom. It needs to be flat - as it will be when glued to the sides - when fitting the braces. The tendency of the moulded soundboards, because they have been moulded into a complex three-dimensional shape, is for the edges at the widest point of each half to follow the curve in the middle. By the time the graduating is done it is flexible enough to be clamped flat.

Draw the position and outline of the bridge on the inside of the soundboard as well the position of the braces, as per the diagram. The braces are made of 8mm x 20mm brace stock and should end 40mm from the outline on the back edge of the soundboard and 35mm from the outline at the front.

Cut the two braces to length and mark the top end of each one with a number (1 & 2 for simplicity's sake). Trace the curvature of the soundboard onto each brace with a short stub of pencil and cut the marked area away with a chisel or sand it off. This will need to be done a few times until the brace is roughly in contact with the inside of the soundboard along it's whole length. The bottom of the brace will be need to be curved in two directions to fit the contours of the soundboard, rather like a twisted ribbon so it touches along it's entire length, and width.

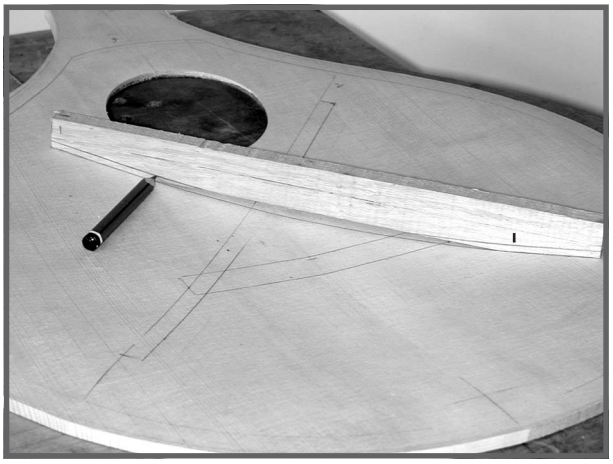
Place a strip of carbon paper, or ordinary paper rubbed with chalk on the soundboard over the pencil marks and rub the brace back a forward a couple of milimetres. Chisel away the places where the carbon or chalk has marked and repeat until the braces sit fully on the soundboard. Make sure the brace is held upright, and not tilted over. Remove the soundboard from the moulding caul.

Mark the crossing point of each brace and cut notches that are 7.5mm from the soundboard surface. The finished braces will be 15mm at this point, hence the 7.5mm notch. Check the fit of the braces on the soundboard when notched together. Glue the first brace (the one with the notch facing upwards!) in position, holding at each end with a cam clamp and then add other clamps along the length. Clean up any squeezeout.

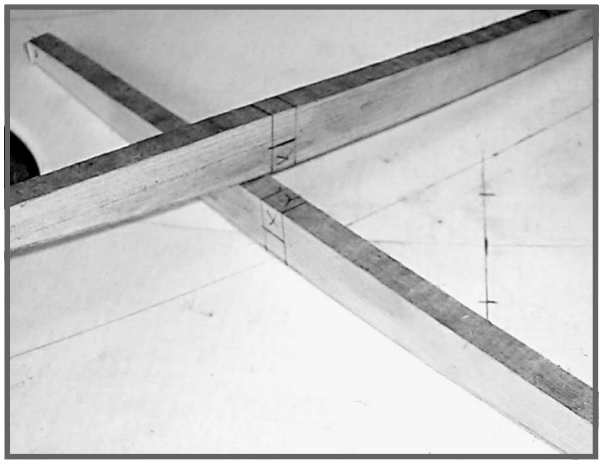
Leave it for an hour to dry and repeat for the second brace, putting a couple of drops of glue into the notch before fitting. Leave that overnight to dry. Tap the soundboard again. The frequency will have risen, this one up to C#. This will be too high a pitch, and the braces will have to be carved down.

Clamp the soundboard back in the moulding caul again, and carve away the area around the crossing point to 15mm high, and then taper the rest of the braces to 3mm at each end, following the curve of the soundboard.

Tap and measure again. The final note on this instrument was B, but a range of A to



Tracing the soundboard courve onto the brace



Marking the crossing point

C should be fine. If still to high scollop out 2-3mm between the crossing point and the bridge position and taper the tops of the braces to a point.

These braces are not so much supporting the soundboard and the string tension as controlling the soundboard resonances. These resonances will change quite radically when the soundboard is glued to the sides, and then again when the final carving is done around the edges.

The soundboard can now be glued to the sides and block assembly.

When making any instrument, it is good practice to write down the tap tones at progressive stages of soundboard construction. After listening to the finished instrument and noting where the tap tones occured, it becomes possible after a few instruments to start to to control the sound by controlling the tap tones. It is a mix of art, science and intuition, but it does help.

With 7mm Englemann spruce moulded, glued up and cut to shape, there was a strong resonance between C and C#.

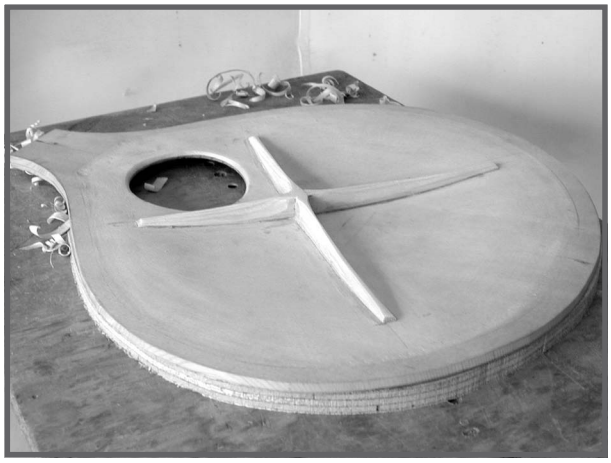
Carved to 6.5mm in the centre and a little over 3mm in the channel, with edges at 5.5mm there was a resonance at C an octave higher and another strong one at F# (another one of those mysterious things which I don't really understand). With the soundboard carved and sanded down to 5.5mm in the centre and 3mm in the channel the note dropped to B. Cutting the soundhole dropped the note again to between B and A# and when 8 x 15mm X braces were glued on it rose again to C# an octave higher.

Profiling the braces brought this down to between C and C# and carving the braces down to 3mm high at each end dropped the note to B.

With the top glued to the sides and the headblock fingerbraces glued the note went up again to G#, with the edges still a little thick and a 10-12mm wide area between the channel and the binding still too thick. When the back was glued on the air resonance was a little above C and when final carving and sanding was completed the air resonance was right between C# and D, which stayed much the same after lacquering.

Again, these frequencies were within the expected ranges that other similar instruments have exhibited. The critical factor is the resonance of the free plate before it is glued to the sides. Somewhere between A and B is optimal. I built one moulded top arch-top which was entirely too stiff, with a free plate resonance of D. It exhibited lots of unpleasant overtones and I eventually replaced the top, which improved it dramatically.

Gluing the soundboard braces



The inside of the finished soundboard