SETUP

Setting up the instrument is the last stage of the making process, before the final adjustments. It involves all of the things that the strings touch, plus the soundpost—the final touches that make the instrument playable. In larger shops setup is often considered a specialty job, similar to bow rehairing, because it's a critical skill different from making and restoration that benefits from constant repetition. Many makers, if they haven't worked at some time in a shop doing a lot of setups, are minimally skilled at setup and treat it as the final impediment to getting an instrument playable and sold.

Learning setup mimics learning to make: initially it is a job of numbers and measurements, discovering and doing something that works most of the time and is easily quantifiable in lists of dimensions. Only later does it blossom into a more creative and flexible discipline, determining in conjunction with adjustment the most precise aspects of how a violin performs. Because of this, there have been people in the violin world who have made famous reputations based primarily on their abilities at setup and adjustment. It's not uncommon for players to run directly from buying a new violin to their favorite setup and adjustment person to set things really right for them.

For easy organization of this section, I'll present setup from the top of the instrument down, but that's not necessarily the order in which operations have to flow.

Fitting Pegs

The first point of interaction between a player and the violin usually involves the pegs and tuning. Players are particularly sensitive to an instrument which doesn't work, and pegs are fickle. Ideally, a peg turns smoothly without excess pressure, and stays where it's put. Unruly pegs click and jump back and forth around but never exactly on the pitch being targeted, and in spite of moving stiffly, don't seem to want to stay where they're set. Fitting and lubricating a peg isn't difficult, but it must be done precisely. Anything short of perfect can rapidly become non-functional, but a peg which is done properly will work properly for a long time—there's no mystery about it, beyond care.

Criteria

- All pegs should be parallel to each other, and straight to the axis of the instrument itself, not square to the walls of the peg box. Be sure to view from the front and the back, and from above, relative to the edges of the top and back.
- Pegs should project equally from the peg box walls, 35-37mm to the end of the peg, not within that window, but all set the same, and not including any decoration on the end of the peg. Some shaped cases will not fit if the pegs extend farther. New pegs quickly wear in and humidity changes can affect fit, so a peg that extends 37mm can become a peg that extends 35mm within a couple of months. Burnishing in and compressing the peg holes can help limit this.
- Pegs should fit perfectly: when fitted properly they will not wiggle in either hole if dropped in gently, but will fit equally tightly in both sides of the peg box, and when lubed and run in, will have two equally polished and continuous rings around them where they bear against their holes in the peg box walls.
- The entire shaft and the end should be sanded with 220 grit sandpaper and then with 320 grit sandpaper and oil, at the minimum. Sanding to 400, or even to 600 grit, is appropriate for better instruments. Sanding should be even and not excessive so as not to disrupt the taper of the peg, damaging the fit!
- Ends of new pegs should finish slightly within the outside wall of the peg box, about 1mm inside, to account for some initial seating in through use.
- Ends of the pegs should be attractively finished slightly domed with sharp edges where the dome meets the shaft, and string holes properly placed, 1/3 of the way across the inside of the peg box from the peg head side, facing the player when the flat of the peg is turned forward, and finished with a small file bevel as described in the procedure.
- Pegs should be lubricated so that they turn easily, but stay where they are put.

Peg Shapers

I prefer the all-brass, three-holed German type. (Alberti Designs makes a more sophisticated and expensive version of this that is functionally even better). The smallest hole, which has a maximum shaft diameter at the peg head of 6.5mm, is used for violin pegs, and the middle hole for viola. On an old instrument, when the holes are worn, using the next larger hole size is permissible, but if pegs larger than that are needed, the peg holes should be bushed.

Intermediate sizes between the three holes can be achieved by placing a 6mm wide slightly tapered, say to about 5mm, strip of coarse sandpaper long enough to hang out both ends of the hole, sand surface down, biting on the bottom of the hole in the shaper so that it doesn’t move, which pushes the peg upwards towards the blade, making the resulting peg slightly smaller. Strips can be stacked to make the hole, and thus the peg, even smaller, if necessary. That I mention this option in passing should not be taken that this is commonly done—only that it may be, for instance, the way to save reaming a peg hole up to the next shaper hole size on an old violin, or on a new one where you've inadvertently reamed too deeply.

The shaper blade must be adjusted before use to exactly match the taper of the individualy reamer that will be used. Because some reamers have a warp from one end to the other, you can't simply adjust the shaper against the reamer by putting the reamer in the shaper and pushing the blade against the shaper. The only way to do adjust the blade accurately is by trial and error, making very small adjustments combined with testing the fit. Instead of a real peg, a stick of wood can be trimmed in the shaper to sample the adjustment against a hole freshly reamed in a solid piece of wood with the appropriate reamer. If you cover the stick with peg dope, the hole in the wood will polish the dope where the fit is tighter, and you can read the fit from that.

Shaper blades are sharpened more bluntly than any other cutting tool, and don't think things will go better if you change this. If you want to go in any direction, head for blunter: shapers designed for scraping work more cleanly than cutting ones, but very slowly. When it eventually comes time to sharpen the blade, measure and record the gap between the opposite ends of the blade and the opposing lip on the shaper, right at the clamping screws. When you replace the sharpened blade, you can set these gaps to the previous dimensions, and not have to go through the entire adjustment procedure again. It's sufficient to hone the bevel on your finest stone; more likely, you will see lots of wear on the bottom, flat side of the blade, and vigorous stone work on this side with coarser stones, then finer ones, will flatten out this wear. Avoid having to regrind the edge. It's not impossible, but the small blade is hard to handle on the grinder. When regrinding, use the same method I use for larger blades of setting the grinder to grind from the center of the bevel outwards, and avoid touching the honed edge—stop just short of it, and finish on a stone. Since the peg shaper relies on a very straight edge on the blade, work to keep the edge accurately straight.

If the blade sticks out too far into the peg it will cut quickly, but leave a rough cut. This may be all right for the largest hole, which is rarely used for finishing, but for the two smaller holes the blades should be adjusted to take the absolute minimum cut. A particularly clean and polished cut results if the peg must be forced into the shaper a bit before any cutting takes place, but this is not always possible to set up. In general, remember that shapers and reamers rarely match, so any difference is compensated for by the blade adjustment.

Reamer

Though a normal-sized 1:30 peg reamer will work, the smaller ones made for small sized violins are perfect for most new instrument work. The smaller size allows a smaller pilot hole, which allows more space to align the holes if they have not been perfectly placed in the original drilling. If you're doing repairs, the smaller size is good for starting holes in new bushings for the same reason—lots of room for adjustment. The proper size for 4/4 violins is reached near the large end of the reamer. For violas, a full-size reamer is required, however, and that's also fine for 4/4 violins that have had larger pilot holes drilled, if they are properly positioned.

Modern violin peg fitting is always done with a 1:30 taper, but if you work with old instruments you often will be faced with 1:20 holes as well as varying steep tapers from machinists' reamers. It's handy to have a 1:20 reamer and shaper around for working on these instruments, both for fitting pegs when the original holes are small but may need rounding up, and for bushing jobs, where having the right reamer eliminates the need to excessively ream out new wood in the pegbox. In a pinch it's not too difficult to file-fit a set of pegs once in a while, so you might not need a shaper, but there's no substitute for the reamer.

Reamers should be stored in paper tubes, kept clean by removing shavings with a marking point or something similar without touching the sharp edges, and must never be allowed to bang against other tools. They last very long if cared for, but once damaged cannot be resharpened effectively.

Saw

A small dovetail saw is required to trim off the peg ends. Almost anything with fine teeth will do, even a small Exacto saw or a coping saw.

Drill

The string holes in the pegs are drilled with a 1mm or 1.5mm (1/16") drill. An electric drill is efficient, more accurate, and easier to handle than a hand drill for this job, and drills a cleaner exit hole, if used at its highest speed.

Files and Sandpaper, etc.

The minimum for this job is a six-inch, coarse flat file (00 hand file), a needle file of the type used for filing string grooves in nuts and bridges, sandpaper in several grits, and mineral oil. Peg dope, or pumice and soap, will be needed for lubrication. My favorite commercial brand is Hill, but it must be fresh (not dried out).

Shaping

Begin by turning all of the pegs to the same size in the shaper. Start with the largest hole where cutting takes place, and work down through the sizes to the final hole required.

Several problems can develop shaping the pegs. If a peg is seriously warped along it's length, the far end of the shaft won't be pointed towards the center of the head, and in the course of shaping the bent end will direct the shaping to end up off-center at the head end. If this is the case, the best correction is to begin shaping in an adjustable shaper, or in a larger holed shaper shimmed with sandpaper so that the whole length of the peg starts being shaped at once and remains on-target. The adjustable shaper is the easy solution, but they work so poorly that I'm reluctant to suggest that a beginning maker buy one. The only one that I have tried that actually works, and does so well enough to replace the normal three-hole and four-hole versions is the German Wirbelschneider. It's expensive, but performs exactly as promised in the advertising, and is very easy to set and resharpen. Also, it can be quickly set to any desired peg taper, once you have done it once and recorded the appropriate measurements from the shaper.

Pegs with particularly wild grain can trim roughly, with a lot of tearing out of the wood. If this happens, often the best approach is to turn the peg rapidly and gently, but not push it into the shaper too strongly. Every once in a while you'll find a peg with such wild grain that it will grab and break apart in the shaper. This is a good reason for standardizing on one peg style and buying multiple sets, so that you can mess up an occasional peg without panicking.

The collars at the end of the shaft near the head are always vulnerable to being broken off, since the blade begins to cut very deeply as it approaches the head, making a large step in the shaft thickness near the collar that breaks up in large slivers, inevitably breaking the collar. The solution to this is to use a sharp knife or small saw to score the shaft next to the rings, and/or when approaching the rings move back to the previous hole, push the peg in all the way, and then shave off the step that has developed in the shaft by pushing upwards against the blade while shaving the step off, then moving back to the proper hole to clean up and finish.

When the pegs have been shaped, sand them with 220, then 320 wet-or-dry paper, and finally 400 and oil, being careful to sand the whole length of the shaft equally. Start with the finest manageable grade, and the final sanding should be with the grain.

Fitting

Start with the G peg. This is the lowest peg in the peg box and enters from the left side.

It’s a very common error to start with the E peg in the lowest position, which will necessitate bushing this hole, and three others if it’s not immediately discovered that this has been done!

Ream the hole, being careful not to push the reamer up or down, back or forward. It’s too easy to ream the peg in crookedly, just by inattention. Likewise, it’s easy to straighten a peg by tugging on the reamer in the appropriate direction while reaming, but this should be done early enough that there’s time left to then ream the oval hole that results out to round. The pegs should be parallel to the edge of the back, when they’re viewed from the top, and perpendicular to the centerline of the instrument when viewed from the front and back.

As soon as enough hole has developed to put the peg in, put one in and measure the distance that the peg projects, to the end of the peg head. Note how much farther the peg must go in to achieve the perfect 37mm projection, and then place the reamer in the hole and measure out to figure what location on the reamer will put the peg at the right projection, and then wrap a piece of masking tape around the reamer at that point. Continue to ream the peg in, measuring regularly (don’t trust the tape) and when the peg projects 37mm when firmly twisted into the hole, adjust the tape on the reamer so it just touches the peg box wall, to act as a visual stop. This will help prevent reaming in the other three pegs too far, but it should not be trusted, since the pegs may vary slightly in size. In order to assure that the pegs won’t quickly wear in deeper is to ream the last three millimeters or so by turning the reamer backwards. This compresses the hole, as the peg will in use, rather than cutting it, and results in a more stable setting. The earlier you can get a bit of peg dope on the peg, so that you can turn it in farther without binding, the more accurately will your final projection will make it through without changing. From this point on you should dope the peg early and often.

As the pegs are fitted, keep track of which goes in which position, and when all are adjusted, make the following three sets of marks: a pinprick where the small end of the peg comes out of the peg box wall, where the end will be sawn off flush with the peg box; at the proper location of the string hole, 1/3 of the space across the peg box from the large end of the peg; and under the head, one, two, or three pinpricks, indicating the E, A, and D string pegs--the fourth peg, the G, won’t need anything to identify it, since it will be the only unmarked peg.

Remove all the pegs, and saw the extra ends off, just .5mm inside the mark made to indicate the peg box wall. First file the ends flat to remove the saw marks and square up the end, and then file a bevel around the end of the peg, at about a 15-degree angle, leaving a tiny flat spot in the exact center of the tip of the peg. Make sure the filing is neat, and leaves a clean, not wobbling, line around the circumference of the peg. I do this by holding the file like a pencil, and filing down while simultaneously spinning the peg. Then sand with 220 and 320 with oil, polishing the ends of the peg into a sharp-edged flat dome that's not more than about .5mm high. The end of the peg should end up about 1-2mm inside the outer wall of the peg box, and it will very quickly wear in so that it is level with the outside surface. File a small grove across the top of the string holes, removing the ragged drill mess, leaving a cigar shaped ramp over the hole that the string can follow out of the hole.

Lubricate the peg with lots of peg compound, or soap, and work it in well, adding more until the hole is well packed with it. At this point, there's no such thing as too much. Lacking fresh Hill peg compound, in a pinch soft bar soap can work as well if you don't mind a bit of slipping, initially. One tiny dab of pumice will help a peg that still insists on slipping after a day or so.

Making a Nut

In the order of things, the nut is put on the board after the board is on the neck, before the neck is shaped, and the ends of the nut, the sides of the board, and the neck shaped as if they were one continuous piece. The process below is for a nut alone, and would be slightly different and easier on a new neck.

For the nut you'll need a blank of ebony, your 102 plane, a small saw, files (coarse and fine tapering half-round files are nice for this if you have them), the usual grades of sandpaper, and a mouse tail nut file. The mouse tail file varies in width from one end to the other, and it's not necessary to fit the groove sizes precisely to the strings, so fancy graduated single-purpose files aren't necessary.

The best way to get an idea of the complex flow of curves making up an ideal nut is to look at the real thing. The sides of the fingerboard should appear to flow continuously through the nut, and the back is tilted to match and continue the tilt of the bottom of the pegbox. On the finished nut, the bottom is ideally 6mm wide, diminishing to 4.5mm on the top, where the strings ride. The most complex part of the nut is the top surface, which is a slightly rounded band, tilted backwards which wraps around the back corner of the nut diminishing to nothing where it meets the pegbox. The front of this surface should point the strings out straight over the board, and at the back it should point the strings directly at their respective pegs. The top accomplishes this with a smooth curve to transition the flow of the strings over it gently. Viewed from the side, the strings shouldn't bend either on exiting or entering the nut.

String grooves should be just deep enough to to keep the string from slipping off the nut and as wide of a curve as the string or wider (use the appropriate section of the file for each groove) so that the sides of the groove won't pinch the string. A depth of one-third of the string thickness is often mentioned, but even less is better. At the board end the string should leave the nut pointed just a bit upwards, so that the take-off point for the string is really right at the end of the board. The one exception to this is the A string, which is so fragile that this tiny edge can catch and damage its winding. The groove for the A string should break just before the edge of the nut, by making a last very light file cut with the file resting on the board, making a tiny funnel shape to lead the string up onto the nut.

Start by making sure the end of the finger board against which you'll glue the nut is perfectly flat. It's OK to scrape that a bit hollow and then take one final neat file pass to flatten a rim all around the surface for the nut to rest against, assuring a seamless invisible fit. Plane the side of the nut that will be against the board first, then the bottom, matching the right angle fit by trial and error until it's perfect. Finally, plane the back to the necessary angle defined above, and sand this back bevel to 400-grit, at least. If possible the joint between the back of the nut and the ramp inside of the pegbox should be continuous and perfect. On some older violins the space for the nut may be narrow, and if it works you can fit a normal nut on, overhanging the pegbox, and then fill the empty space to make the ramp continuous with something like plastic wood, stained to match the inside of the pegbox. This is one place where wood is too much bother and wouldn't be noticed anyway.

Saw off the length of the nut so that it overhangs the board on each side by about .5mm, and glue the nut in place with one or two tiny drops of glue. Any glue, including super glue, is OK, but don't use so much that it spreads everywhere. Coating the bottom of the nut with wax isn't a bad idea, so that it won't be glued to the neck, making problems later when you have to remove it for dressing the board.

I glue the nut on full height because it's easier to cut the height down while it's glued in place, but if it's very tall I may quickly chop most of the extra off by putting the blank in place, scribing with a penci marking where the top of the board meets the nut, and cutting down to about 1mm above that line. Glued on or loose, I do this quickly with a chisel or knife, glue the nut in place then clean up the top quickly with a coarse file, temporarily. Next I work on the ends, first with a knife and then files, trimming them until the blend with the sides of the board. This is a whatever-works situation, and I use both flat and rounded files, Last, I scrape the file marks off and finish with 400-grit sandpaper on a small block of wood. Then I go back and get serious on the top, making it a bit higher above the board on the G side than the E, with a slight backwards tilt towards the pegs. Next I mark the strings and file the grooves, to the right depth, and at that point will probably have to lower the top again in places and file the curve back towards the pegs more accurately, to follow the string grooves. If you have filed the right curve into the grooves, you can file down the nut until you know the top follows the curve of the groove by the grooves being equal width through their course from the front to the back of the nut.

The grooves are centered on the board (that is, there's an equal amount of board hanging out beyond the strings on either side. and the E to G spacing is 16.5mm. Use a dividers to mark these two points on top of the nut, eyeballing the distance from the edge of the board. Then strike off the two points for the D and A strings by setting the dividers to 5.5mm, and marking each string's position. I like to start the grooves with a triangular file, making a little cut so the round file can't wander, and then continue with the round file. Check the spacings as you go with the dividers, and be especially accurate about the spacing and centering on the board. The final depth of the grooves should hold each string about half its diameter off the board, with the E set the same as the A.

When the grooves are finished, finish file the top. At this point you can file the top to wrap around the back corners of the nut, diminishing to nothing at the pegbox (refer to the photos to see how this should look), and then sand that with 220, 320, and 400-grit papers. Be careful not to round things over excessively. The various junctions of each surface on the nut should be sharp, and the diminishing triangles of the ends of the top should be as flat as possible, which means using some hard backup for the sandpaper. The back of the nut can be left as it came from the plane. Finally, run a pencil point through the grooves for lubrication.

Making a Fingerboard

To make a fingerboard you'll need an appropriate blank, the right template for the violin board top, a 102 plane, a marking gauge, bendable scrapers, a small flat gouge, a small round-bottom fingerplane, a small saw, and the usual collection of sandpaper. Board and bridge top templates are available as a standardized kit—everyone uses the same set, which eliminates a lot of replaning that used to happen from shop to shop when there was no standard. The violin and viola templates are circular, and easy to make at home. You'll also need to make a jig to hold the board while you're working on the top. This is simply a piece of board the same widths as the finished board but a bit longer, with wood rails glued on its sides that hold the board between them when the board is slid in from the wide end. Another block of wood on the bottom allows this fixture to be clamped in a vise. Any wood is fine for this and mine is a mix of what was lying around the shop.

Start by flattening the bottom of the board, planing with the thin end of your blank against a bench stop. Since board blanks often come with a little hollow curve in them lengthwise, you may need to place a folded piece of paper towel under the middle of the board to be able to plane the middle without it just bending down away from the plane.

Check the flatness with straightedges and ideally on a flat piece of marble, sighting all around for a good fit. You can plane the bottom a little hollow down the center so the edges click down nicely on the marble slab. Make sure there's no twisting by alternately tapping either end down, and watching for a twisting jump. With rules you can check twisting by the same winding stick method you used in joining and flattening the top and back.

When the bottom is flat, plane the board to the proper width. This is 24.0mm at the nut, 32.0mm at the end of the neck (about 137mm down from the nut) and 42 or 43mm at the bottom, 270mm from the nut (you may have to saw off one end of the board if it's a bit long, but save this for last). Be sure the sides are planed square to the bottom, and in order to meet the above measurements you'll have to make the sides slightly scooped in length, not flat, which may mean rotating your plane a bit left or right (the more you turn it, the deep the scoop you'll make). Plane from the wide end of the board up to the nut, and use a rule as a straightedge to make especially sure that the sides maintain their slight hollow all the way up to the nut end. There will be a tendency to round over a bit at the end which can be negated by stopping just short (within five or ten mm) of the end of the board when planing, and cutting through to the end only once in a while as necessary to continue the flow of the sides. Fitting a board to an existing old neck is a little more complex, since you have to aim for the ideal widths while dealing with a neck which may not permit them. This, being a repair topic, isn't covered here, and it requires a lot of juggling and hand-holding the first couple of times from someone who knows where you can cheat to make things work.

When the width is perfect, it's time to start on the top. The sides of the board should end up 5mm thick, and since rounding the edges of the board later to blend them into the neck increases the apparent thickness just a bit, I start with 4.8mm. Set a marking gauge to 4.8mm, then, and scribe lines down both sides of the board 4.8mm up from the bottom. Then take the 102 plane and start planing off the extra while fitting the top to the curved board template. All planing is from bottom to the top of the board, unless the board is quirky. This process is unreasonably complex, and I have a couple of tricks to help. First, I tilt the plane at about a 45 degree angle, and plane a bevel on the top corners of the edges down almost to the marker's scratch on the side. Use this opportunity to make that line straight and equally above the scratch from one end to the other. Then I run the template over the top, and start by making the worst spots fit the template better. Then I blend everything together from end to end with long smooth plane strokes. I try to make a good match to the template relatively early, and then simply and neatly gradually lower the top until the edges touch the scribed lines. If the scribed mark is difficult to see, you can rub white chalk on the line and wipe away the extra, leaving a white line. There should be a slight scoop in the length of the surface, about .75mm under the G string, and .5mm under the E. This will almost happen without your effort, but it should be regularly checked as you work, and it may be necessary to rotate the plane a bit to accomplish this, especially on the G string side.

If you're very clever, you will eventually realize that what I've outlined above can't possibly work. The objective is to have .75mm of scoop under the G, .5mm under the E, and something between this under the other strings. Let's estimate about .6mm of scoop down the center. . . that would be about right. But as I've outlined it above, that can't happen. Imagine for a start that you needed no scoop at all. For the center this would be easy, but how about the outside strings? Take a ruler and put it on a round oatmeal box. Put it straight up the box side, and imagine this is the center of the board. Now move to one side, over to the Oatmeal G, and tilt the ruler to follow the widening string path. As soon as you do this you'll realize there's a hump: in order for the path to be straight, the cylindrical box has to be planed hollow! The same thing happens on the other side. What that means is that the arch at the middle of the board, around the bottom off the neck, can't follow the template for the scoop to work right—the arch has to be a bit rounder in the middle than at either end. If you make the template fit, you'll have too much scoop under the middle strings. You can make this all work when planing by making sure the shape of your board matches the template at each end, the shape is rounder in the middle, and the scoop is the ultimate determinant of the actual shape of the board approaching the middle.

Another way to accomplish this would be to make the board surface conical—rounder at the nut, and gradually flattening towards the bridge. The reason this won't work is because the center strings will, with the existing template, be a little higher off the board at the bottom end than they really should be. Flattening the board at the bottom will make this situation worse. The alternate is rounding the board more at the top, but doing this makes the board too round at the nut. The compromise I have chosen is a compromise that makes everything sort of work, without doing anything too extreme.

As you approach the final surface, make sure your plane blade is retracted to the finest cut, and concentrate on making the surface as facet-free as you can make it with the plane. Check often with the template. Wetting the board and then squeegeeing down the length with the template makes it very obvious where the template touches for both the final planing and for the scraping that follows.

After you've planed it to your satisfaction (for me that means that I don't think planing more will make it any better or smoother), move to scraping. I use either a flexible scraper bent to do the whole surface at once, or I also have a scraper with the approximate concave curve ground into it. This was ground by placing it on my grinding wheel so that the steel is in line with the wheel, and tilting the whole scraper left (or right) to about 45 degrees. The arc doesn't have to be precise—you're not going to work on autopilot, and still have to watch what's happening and act accordingly.

First I scrape, using the template and water as before until I know I've scraped out all of the plane flats. Don't make every scrape square to the board straight down—rotate the scraper left and right, too. Otherwise you will make and reinforce chatter down the length. Next, take a flat, stiffer scraper, and scrape sideways slightly diagonally to remove any chatter and local bumps. Start near one edge and scrape towards the center of the board; if you go all the way across and off, you risk pulling out slivers of wood on the exit side. Finally take a few long passes with the flexible scraper to remove cross-scratches. We will sand the top of the board much later in the process, during the setup stage.

Now is the time, if necessary, to saw any extra off the board beyond 270mm, and file, scrape, and sand the bottom end beautifully smooth and perfectly square. An adjustable try square is good for checking the squareness of the end. You can cut from either end—by this time there may be an error in width you want to correct and this is an opportunity to help that by picking which end to saw off. The nut end should be similarly finished, but not through sanding, since it won't be visible.

The board isn't on the neck yet, and the last step before you can do that is to finish the underside by finishing the rough hollowing that the board blank came with. The objective here is to make most of the free-hanging end of the board 4.8-5.0mm thick. Start by setting your marking gauge to 1.5mm, and scribe a line on each side to mark how close the hollow will come to the edges. At the upper end of the hollow, 6mm from the end of the neck, mark a circle that will be the end of the hollow, and proceed to thin the board with a gouge, fingerplane to, and finally a scraper, to an almost-finished state. Pay close attention to the end of the board where the player will be staring—the underside should match the top curve, and be true and clean, not lumpy. I leave this for last, having left that end just a few tenths of a mm thicker, and work the line with a half-round file until it's perfect. Then sandpaper the hollow, making the underside as well finished as the top.

In the making process, this is the point at which the board is glued to the rough neck, and then the half-finished nut is glued on. When the neck is subsequently carved, the sides of the board and nut are finished and rounded with the neck carving.

For a new board on an old instrument, this is the point that the board is glued on, followed by the nut, and then the sides of the board and nut are faired into the existing neck, rounding the board edges as will be explained elsewhere. This is not a haphazard thing, so if you're reading this section for repair, not making, read how that's done in the neck carving section.

I leave the board scraped at this point, with only a little preliminary sanding with 220 grit. After the neck is finished, the edges shaped, and during the final setup process, it's time to do the final sanding, using the sandpaper on a flexible backing (I use a rubber block about 6mm thick), going through all of the grits to 400, and finishing with oil sanding. I often leave the sanding until after the violin is varnished, so that I can remove any marks and varnish drips the top picks up in the intervening period.

After the top has been sanded, and the nut finished, the very last thing you need to do is break the sharp upper edge along the length of the board on either side. I use a mill file to put a small (.5mm) 45-degree bevel on this edge, and sand that smooth with 400-grit into a very small rounded edge.

Therapeutic Fingerboards

A therapeutic fingerboard is a board that doesn't point where the neck is pointed. This is a way to effect some of the changes offered by a neck set, without removing the neck. The specific directions involved are higher or lower pitch, the equivalent of tilting the neck forward or back; left and right, for a neck that's pointing diagonally; and tilting, when it's desirable to raise or lower the E side of the board relative to the G side. This is not part of the making process because you should have put the neck in correctly, and I'm mentioning it here for people who are using these directions for restoration and repair work.

Changing the pitch involves a board that is wedge shaped, and the most common use of this is to raise the height of the projection of the board at the bridge, if doing a simple neck pull up is not sufficient. The way to do this is obvious, by making the board thicker at the bridge end than the nut; the question is how far can you get away with, and how to hide what you've done.

I normally like to see a board that's about 5.0mm thick on its edges. To tilt the board upwards I don't just plane more off the nut end, since this would make that end too thin. I'm willing to sacrifice about 0.5mm at the nut, but that's the minimum thickness I will make a new board at the nut. At the end of the neck you don't want to make the neck-plus-board too thick, but usually this will be less noticeable, so with a neck that isn't too thick I may add as much as 1mm at that end, for a total change, with the 0.5mm less at the nut, of 1.5mm. This is enough to raise the strings at the bridge about 3mm!

Ideally, you want the neck thickness to be normal, which is 18.5mm just below the nut, and 20.5mm before the heel. I prefer not to go less than 18.0mm and 20.0mm, and the upper limits are 19.0mm and 22mm, so you can see there's more room at the heel for additional board thickness.

Additionally, if the neck Is unusually thin, I will try to build in compensation for that, so if the neck with a normal board measures 18mm, I will try to make it come out 18.5mm with my special board, or even if I'm fitting a normal board I will make it thicker as necessary to achieve this. At the other end it's often necessary to make a thicker board because the front of the neck gets planed down more easily at this end, and even when fitting a normal board I will take this into consideration, making it thicker to achieve the right thickness at the heel.

Tapering the neck in the other direction, thinner towards the bridge, is rarely necessary. I use about the same figures as above, considering that the thinnest, 4.5mm, needs to be counted at the widest end of the board, not at the heel.

The way to hide what you've done is by taking wood off the bottom of the board to establish an even-thickness edge throughout the whole free-hanging length. I do this with a fingerplane, finished more precisely with a file. At the end of the heel, rather than making a step, it's permissible to gradually increase the board thickness in the last inch or so in a clean arc towards the bottom of the heel that shouldn't be noticed.

Adjusting the E-to-G side tilt is done similarly, by making a board that's thicker on one side than the other. Again, the free-hanging portion of the board should be adjusted so that it's the same thickness on either side.

Making a board that's pointed sideways is a subtle way to change the left-right directions of a neck set, but it can't be carried to extremes or the board won't work. The trick here is that instead of making the board concavely scooped on both sides, one side is straightened, and the other made more concave. This bends the whole path of the board sideways, and this is good for about 1mm of adjustment at the very most (that is, 0.5mm taken away on one side, which will make it straight, normally, and then the 0.5mm added to the scoop on the other).

Fitting a Soundpost

Supposedly the French word for soundpost equates to our word for “soul”, with the idea that the core of tonal adjustment centers on the post. I don’t especially agree with that, but it is true that a bad post can go a long way towards ruining the sound of a violin. The points to watch for proper post function are fit, tension, and location.

For a start it’s best to do all of these normally, and then vary them as necessary for tonal reasons. For me, the correct starting position for the post is 1mm inside the outer edge of the bridge foot, 2.5mm south of the bridge. The correct tension is just beyond what’s necessary to keep the post from falling, not jammed in tightly. The post should stand vertical in all respects, and this requires looking at it from many different angles, through both f-holes, and both closely through the end button hole, comparing to the interior features of the body, and at a distance through the end button hole so you can also see it in comparison with outside features. In fitting the post it can't be adequately emphasized that the post has to go back into the same position, at the same angle and tension during the whole process. This is especially important in old instruments where you may be working around dents and might have to fit a post that stands partly on the edge of a depression and partly in the depression, with a step. I always try to navigate against something like a grain line or mark in the wood, and putting a small pencil mark on the back to help locate the post is OK, though I don't do that. Some makers plot the initial position of the post while the top is still off, and mark the post location on both the top and the back. I usually only mark this on the top, where it won't be seen so that I don't have to be continually measuring the post position while I'm fitting it, but as I approach the mark I no longer trust its exact location, and in the final fitting will always measure with a rule. If you work on old violins, leaving your own marks inside is considered bad manners, but there are always enough landmarks on old wood to remember where the post goes.

The tools required for setting a post are a flat-honed, straight edge knife (mine is a 16mm blade), a post setter, and a cheap metric rule with a bent end to enable it to enter f-hole and still reach the top of the post. Look at the photos to see details of how these tools are made. My post setter shaft has been thinned so that it may be turned in any direction without touching the sides of the f-hole, and rounded all over so that no damage will be done if it does contact the fragile f-hole edges. Some makers use a piece of heat-shrink tubing on the shaft, or a strip of electrical tape for a buffer. Rather than being broadly S-shaped, a pretty but non-functional approach, both ends of my shaper are tightly bent to an angle and location that allows the hook or point to approach the post perpendicularly, but which brings the shaft through the f-hole at right angles to the arch, minimizing the possibility of contact. The point is quite reduced in size, and sharp; it's always nice to be the one who makes the smallest hole in the post, as you will find when you try to catch someone else's post that has a smaller hole than your setter needs as it's rolling around inside. My setter is made of tool steel, and is very stiff. Many commercial setters, especially the type with the gently tapered center shaft and cloverleaf end, are made of steel that is too soft to be ground as small as would be desirable.

Soundpost material can be made or purchased. The wood used should not be too wide-grained, but more importantly it should be straight-grained and split, so that the grain lines run true and straight through the post, not diagonally from end to end. Cut-offs from violin tops are fine, as is wood for bassbars, scraps, etc. If you make your own, use as long of a piece as you can handle and make multiple posts at once. About 18 inches is a good length. Commercial posts should be about 6.3mm in diameter. If you find a source you like, buy a lot at once, because second-rate posts are the norm. I don't see an advantage to making my own, as long as I have a good source.

Start by cutting a section of approximately the correct length. This can be measured by sticking the post stock into the upper eye of the right f-hole until it touches the back, and marking on the post level with the top of the arch in the center of the violin. Remove the post stock and cut it by rolling it on your bench top with the edge of your knife until a deep ring has been cut nearly through the post, then break off the section you will use.

The best way to fit a post is gradually, starting with it standing at the deepest point in the violin, on the center seam, and then gradually cutting away both ends to maintain a good fit and slowly move the post outward into its final position. This allows you a lot of time to sense how the internal shape of the violin is changing as you move outwards (the post ends will tilt not only directly relative to the direction the post is moving, but as you move outwards they will begin to tilt slightly north, as the restricted arching in the c-bout affects the internal shape more and more.

You need to maintain the vertical stance of the post perfectly when analyzing what cuts you wish to make, and you should always have the setter sticking out in precisely the same direction (I always position it coming out of the f-hole at the nicks), not rotating the post randomly. After initial small cuts to allow the post to stand up, position it perfectly upright, with the setter aligned, and look at it from every possible angle, using a small dental mirror to check the fit all around. Twist the post in place to see where it contacts the top and back. I do not remove the setter while checking—leave it hanging out of the f, but be careful not to dent the f-hole edges. If it is tight in the post, it won't sag and touch them.

Cutting the post, you should aim for removing the thinnest possible sliver of wood in one cut, taking a piece that is the whole diameter of the post. If you just want to make the post shorter, the wafer of wood should be of enven thickness. If you are trying to adjust the fit, it should be wedged in thickness. Avoid chopping away bits of the end of the post: the cut shold be one flat cut. Though the inside is slightly rounded, this will not be the case for the very small area of a 6+mm area. Practice cutting a good thin wafer, and if you need to do something other than perfectly flat, to stand on a stepped dent in the back, you will have to do that at the moment it's required.

You risk blasting out slivers on the back of the cut, and so as I cut the post I simultaneously rotate it so that the drag of the blade is always pushing inwards towards the center of the cut end. This and learning to cut a smooth thin sliver of wood are difficult skills but you will learn them quicker if you try to make every cut that way.

Likewise, manipulating the post through the f-hole is a developed skill: don't use shortcuts such as scissor setters or other tools, and you will learn the necessary skill more quickly. To sensitively feel the fit and tension of the post it will be absolutely necessary to use the standard type of setter skillfully.

Cutting the Violin Bridge

Tools:

- large knife for fitting feet: 18mm, rounded shape, hollow ground
- small knife for shaping: 3mm
- 102 plane or equivalent
- bridge arch template
- #3 half-round Swiss pattern or similar fine file
- mouse tail file
- caliper
- 150mm rule
- straight scraper
- 220 and 400 grit sandpaper
- pencil, normal wood type
- airbrush and air source

Materials:

- bridge blank, ideally at least Aubert #7 or higher grade
- drum skin for under E string
- stain of your choice

The bridge is the main passage between the strings, which the player controls, and the body of the violin, which makes the sound. As such it plays an important part in the sound of the violin, mostly as a filter in the middle of the sound production process. The choice of wood and the thickness and size of the various areas on the bridge all play important parts in shaping the tone of the instrument. Don't rush the job: for perspective, a professional job by an experienced worker in a top level shop takes two to three hours; a first-time effort might take five or six, to do a acceptable (not fabulous) job.

The bridge as we now know it is nearly the same as the original design of 400 years ago because it does the job it's called on to do. (The contemporary “baroque” bridge was not the common style in those times, but is a copy of a bridge that Stradivari made for a specially-decorated quartet. Their day-to-day bridges were very similar to ours.) Over the centuries the style has evolved slightly and now there are established measurements and concepts of bridge cutting that are nearly universal among good shops. Following these will bring the performance of the bridge into an acceptable range. Subtle adjustments beyond that can modify various qualities, but the first goal to achieve in cutting a bridge is to gain enough control to make a consistent object which will act in a known way.

Shops and schools of making develop their own styles, which are recognizable and consistent, and as well as being aesthetic choices, can also be seen as responses to the demands of local tonal preferences.

Some measurements and shaping are typical across virtually all styles and represent standards. For instance, the thickness of a bridge at the feet is usually in the range of 4.2mm to 4.7mm, and the top edge usually runs from 1.2mm to 1.5mm thick. The normal width of a bridge, across the feet, is about 41mm. Most of the other features of the bridge also have concrete measurements within a small range, and yet "normal" bridges from different makers with different intents can vary widely.

My goal, then, is not to help you cut the perfect bridge, but to show how to cut one bridge style, and offer advice about what qualities meet general standards in the field, while making a bridge which is aesthetically pleasing to the eye by avoiding some of the common aesthetic and structural errors.

Preparation

Before a bridge can be cut, a number of other things need to be observed and dealt with first. The bridge is the central meeting point of a number of different aspects of the instrument, and depends on all of those various cooperating parts being in their proper places. If they aren't, it's necessary to determine where they are, and if they will need to be, or even can be, corrected first, or whether cutting the bridge will require special compensations to accommodate permanent peculiarities or expensive problems to correct, or problems not within the scope of the job being done in the rest of the violin.

The precise theoretical location for the bridge is standing straight and square between the inner nicks of the f-holes, usually 195mm down the length of the top, centered precisely on the centerline of the top, spaced equally between the two fs, and standing in a defined relationship to both the bass bar and the soundpost. If the violin is properly made, the fingerboard will be centered on that same line, pointed directly at the bridge, and the top center of the board extended out through space to the bridge will intersect the center of the bridge 27mm from the surface of the top.

It often happens that one, or several, of these parameters are out of order—for instance, f-holes can be set unequally different distances out from the centerline of the top, and they can have their nicks placed different distances down the top, neither side being 195mm. The neck can be off center, or centered at the nut but pointed wrong as well as being pointed too high or too low; the arch can be higher on one side or the other, especially on old violins. Perhaps, for instance, the person who set the neck set it crooked by pointing it directly at a bridge which was properly located on the top, but because it was standing on an uneven arch, the bridge's top was displaced to one side or the other (usually the G string side of a top collapses, and the post side rises, tilting the bridge to the G side). The bass bar can be in the wrong place relative to everything else, as can the end pin (which should lie directly on the centerline of the string path).

If everything is straight and right, as it should be if you did everything right, fine. If not, the effect of each problem needs careful evaluation, and a determination made of the strategy which will best correct the maximum number of problems, resulting in the straightest possible string path. For instance, if the fingerboard, bass bar, and endpin are all properly aligned with the centerline, and the fs are mis-spaced, the best strategy may be to ignore the placement of the fs, and base the bridge position on the real centerline. Or if the bar and neck are in a logical line, but the endpin is off, bushing and moving the endpin to the right place is relatively easy. Sometimes the neck appears to be pointed off center, yet measurements reveal that the nut, bar, and endpin are all properly located, and all that's required is to neatly trim one edge of the of the board so that it's slightly narrower, but properly pointed down the middle.

It's not uncommon for virtually every specification on a violin to be wrong--a crooked neck, mounted off center, pointed at the wrong spot, with un-centered f-holes and a misplaced bar, all mounted on a distorted top, terminated with an endpin in the wrong place. The object of a carefully arranged setup is to nudge all of these factors into as straight a line as possible, by whatever means possible. Even if the result is a straight string path running slightly diagonally across the top, this is better than total chaos.

In the neck setting section I show a method for mapping out the centerline of an instrument that enables you to first strike a theoretical center, and then definitely measure how far all of the principal landmarks are from the ideal position. It’s easy to do but complex to explain, so you should refer to the instructions in that section for the specifics of how it’s done.

Every error has one or a number of potential corrections. For instance, if everything is centered, but the top arch is distorted, often simply trimming one foot more than the other in the fitting can make the bridge stand level. Sometimes, additional planing off of one side of the bridge towards the top of the bridge can do even more in this direction, along with strings placed slightly off center on the bridge, but not enough for most people to notice, all summing up to the bridge feet being in the right spot, and the bridge appearing to rise straight from a canted platform on the top, as in the old joke about mountain goats' legs being longer on the downhill side.

Primary in all of this is the concept that the average path of all four strings (the line directly down between the A and D) should be first, a straight line, ideally to within several tenths of a millimeter, and second and less crucial, that this imaginary line should run down the actual centerline of the instrument as defined by the edges and f-holes

Having determined the centering of the instrument and having corrected what can be corrected, and with a plan to compensate for uncorrectable errors, it's time to proceed to fitting the bridge.

Fitting

First it's necessary to choose the bridge blank. A lot of mystique has been made of this. I'll list some of the criteria I've collected, but leave it to you to decide what's you want to be important. Most makers' first choice of bridge blanks has, for decades, been from the Aubert line. The top model is their “deluxe” (identified by the word “deluxe”, stamped over an oval brand), but this is expensive and really only appropriate on the most expensive instruments. Many makers find the #7 model (same oval brand, no “deluxe”) adequate for day to day use, and use the #5 (bearing only the words “Aubert Made in France” on two lines) for student violins. All three of these models use wood "treated" by a proprietary and unrevealed method, but the same models are available untreated, under different model numbers. Recently the firm Despiau has become competitive, with a number of models offering a distinctly different texture of wood from both the treated and untreated models of the Aubert brand. My current favorite, however, are bridge from Milo Stamm. This company has really gone all out to determine what makers and restorers need, and offers a wide variety of both styles and widths, in three different grades of wood. Of all the different brads, the Stamm wood cuts the best, and their styles are so attractive that they could almost be used as they come. But we won’t be doing that.

In the overall scheme of things, a bridge blank is a small expense, so get a good one. Cheap blanks are usually too soft and made of wide-grained wood. Beware of fake German Aubert blanks (usually have stars as part of the brand), bridges branded “Bausch”, “Tourte”, and other off-brands. Some unbranded German blanks are quite good for the money.

The blank chosen should

- be a good color; some people prefer the appearance of the darker Aubert blanks, but I find that they can be punky in texture and difficult to cut cleanly

- have even, fine grain, but not too fine, running straight across
- have no run-out through its thickness
- have numerous and prominent cross-grain flecks on one side
- ring pleasantly when dropped on a hard surface
- make a complex sound when rubbed
- be of sufficiently hard wood to prevent cutting-in of the strings
- be old, aged
- have adequate wood to allow cutting the intended shape
- measure at least 15.5mm across the waist
- be available in the width you require

Some makers dry or harden the bridge blank before starting by heating it on a flat hotplate (in a skillet would work fine) just until the color changes a bit to slightly darker and browner. This is supposed to harden the bridge a bit, which it may or may not do, depending on the blank and the amount of heating, but the color change is attractive. Your experience will perhaps eventually indicate what this does to the tone, and in which circumstances it's desirable, and when it's not.

Start by planing the lower third of the bridge to thickness. For a start, work this to 4.6mm. Do the planing with a small, very sharp block plane--I use my 102, but a 09-1/2 would be fine. Begin by determining if the cut-outs of the bridge are perpendicular to one face or the other by looking at the bridge from the side. Designate the face the cuttings are square to as the back, tailpiece side, and put a pencil mark near the top of the side that will face the board. It does not matter which side the stamp is on, nor which side has the long stripes of cross-figure. There are two opinions on this (one for each side), both equally valid or invalid. One says that the cross figure is stronger, and should reinforce the side of the bridge that is the most vulnerable to collapse, the side facing the fingerboard. The other says that downward forces are more important, and that the rays should be on the back to resist those. I don't think it really matters. Aubert used to, 20 years ago, put the rays on the side that was not perpendicular to the cuttings, indicating that this side should face the board (and many people would ignore this and do it the other way around, necessitating a lot more cutting), but they no longer are consistent in this. Pick a philosophy, rationalize it sufficiently to yourself, and stick with it.

Then taking one pass on the side of the bridge designated the back for every two on the branded side until the bottom of the bridge is 4.6mm thick. You don't need to be planing the whole bridge, but should be working primarly below the waist. At no point do you want to be planing the little dangly thing in the center from the side, which will certainly break it off, so all of your initial planing should be below this. Planing this way, just the lower half, will bring the sides of the bridge closer to parallel, with a bit greater angle to the original face on the fingerboard side.

For planing, hold the bridge in your cupped fingers, with the part of the bridge you want to plane supported by your fingertips, flipping the bridge around as needed. You can plane in any direction that works, but your final strokes should be across the bridge, and you should check with a straightedge or rule to make sure the feet are flat and in line with each other. For this job the plane blade should be extended the absolute minimum so that the cut is a thin tissue, and the blade should be freshly sharpened, since even minimal tear-outs are obvious on such a small piece of work. It may be that the blank prefers being planed in one direction or the other, to minimize tear-out.

Once the final thickness is established the feet can be fit to the top.

Ideally, after the feet have been fit to the top there should not be too much extra height in the feet to remove later from above. Someone with experience will begin by quickly removing most of the extra wood under the feet, getting quickly to close to the right foot height, and then proceed to fitting; however, a beginner can count on using up most of the height of the feet to get them fit, and may eventually chew through the available wood and need to start a new blank, so start slowly.

Generally you want to take as much as possible off the bottom of the feet so that the tips of the feet will need minimal trimming to thickness. This will come naturally, initially, because it will take you a while to get the feet fit, and you'll find yourself desperately running out foot while it's still not fit. This is the only reason to initially used cheap bridges--you may be throwing a few out at the start, if you're intent on doing the best job, and don't mind the practice. However, as your skill level increases, you'll need to concentrate on cutting off enough from the feet. The reason for doing this is that you don't want too little wood in the top of the bridge, between the heart and the top, and you don't want a big gaping area between the arch between the feet of the bridge and the top. Aubert sells a special model of their delux bridge with all the cuttings lower and more compressed for violins with low boards or high arches so that this headwood above the heart is maintained, even with a low bridge, but most people won't have occasion to use that type of blank. Really, if there's not room for a normal bridge (basically, that means the projection of the top of the board to the bridge position will be no less than 26mm off the top--see the illustration), you should repair the violin so that there is room for a normal bridge. This is not only a visual issue; more importantly, it's a tonal issue, so don't try to bypass this. Sometimes you may wish to cut an extra high bridge. If you decide to do this for some good reason, don’t start by cutting as much off the feet as you can—leave a bit extra or there will be too much wood in the top of the bridge.

The object it to get an absolutely seamless, gap-free fit of the feet to the top all around, and this is nearly completely done with a knife with a rounded edge, which permits you to remove only small targeted areas instead of the large and uncontrolled shavings a straight knife would make. I prefer a larger 18mm knife for this job because of its weight, but use only the tip. A rounded knife allows a hollow cut, which comes in handy on old, battered violins where the foot locations can require a very strange contour to the bottoms of the bridge feet. Though jigs are sold to allow rolling the bridge feet over sandpaper placed on the top, the quality of fit obtained by this method is insufficient, and no professional would ever consider using such a method. On an old top, with dents under the feet, this method would, of course, be totally unsatisfactory.

The final height of the two feet should be the same, unless something strange about the violin as previously discussed dictates otherwise, and the centerline of the edge of the bridge should appear to lean back just slightly from perpendicular to the plane of the ribs. Ultimately, because the bridge is tapered, this means the back is actually tilting forward just a bit, and the front of the bridge tilts back quite a bit. With most top archings, which aren’t parallel to the ribs at the bridge position, the bottoms of the feet will end up square to the back of the bridge. Refer to the photos for the appearance of a bridge standing at the right angle.

If you are working on a previously set up violin, remove the strings and tailpiece, if you haven't already—clear access will make this job much easier! Start the fitting by roughly cutting the feet to the contour of the top, and establishing the back tilt. Carry this process as far as possible by eye. In removing wood, concentrate on cutting only where absolutely necessary—where you clearly see that the bridge touches the top, since if a tiny spot of wood is removed from a place where it shouldn't have been, this will necessitate removing wood from the whole rest of the foot to compensate. If you only cut where you can see the bridge is touching the top, the area that touches will get larger and larger until finally the entire foot fits. Don't try to get ahead of this process, even though it's often irresistible. I take at most two tiny cuts between each placement of the bridge on the top to check the fit. If you never cut something you shouldn't, the fitting process will be very quick; if you are tempted to cheat, it will be very slow. Licking the bottom of the foot before you cut makes it easier to remove the thinnest shaving. Having the knife sharp obviously is essential. Work to learn to take off as little as possible. All cuts are made "downhill" on the feet, from the outside edges towards the center. This is the "with the grain" direction essential for a clean cut. It is, of course, absolutely necessary that the bridge be tested on exactly the same spot each time. On violins of no special value, a pinprick into just the top layer of varnish can be made next to the center of the outside of each foot, right at the edge of the foot, nearly hidden. That way you will be able to find the precise same spot each time. On older violins it's often possible to use a grain line and scratches or even the marks of old bridge feet as landmarks for consistent placement each time. To see how important this is, once the bridge fits somewhat, experiment by moving it just a millimeter in each direction, and note the changes in how it fits.

There are two ways to look at the fit: one is to hold the violin and place the bridge in place and hold it there. The other is to simply lie the violin down, and let the bridge sit on the top on its own. The second will give a better fit, because you won't be pushing down on the bridge, and when the strings add extra pressure, everything fits better. It's good to alternate between the two methods. The more different ways you have to look at something, the better the idea you get of what's going on.

You need to be constantly checking one the "back tilt" of the bridge. It really doesn't tilt back much, and the illustration shows you how to check this, using a square on the edge of the top, and comparing that to specific points on the bridge. Essentially, the centerline of the bridge leans back very slightly, relative to the plane of the ribs. The exact amount is such that the back of the top of the bridge is square with a point about 1/4 of the way in from the back of the feet. Don't forget this important thing in your eagerness to get the feet fit, and check it often throughout the fitting process!

At a certain point in the process you will begin to feel that the fit isn't perfect, but it isn't getting any better; that problems continue to exist, but move around from spot to spot, or everything seems hung up on a spot that you don’t seem to be able to see. At this stage, it's time to move to a more sensitive testing tool than the eyes, and that's carbon paper. Thin carbon from credit card slips used to be my favorite; it wasn't too thick, and the carbon was dry rather than thick and pasty as on the normal commercial product, but now that this has become uncommon and unavailable, I use a thin piece of paper on which I've rubbed soft pencil in a large patch.

I prepare two small slips, each clean on one end and blackened on the other, and after positioning the bridge on the top, I lift first one foot and then the other to slip in the paper without moving the bridge from its precise positioning. You must use a slip under each foot because just one paper thickness can tilt the bridge slightly sideways and give an inaccurate reading, falsely indicating that you need to remove wood from the inside of the foot. To mark the bridge, I pinch the bridge between my fingers on one edge near the foot, and press that foot against the top, and slide the paper out from under the other, opposite foot, sliding the paper down on the arch, not pulling it up into the air, which would mark the outside corners whether they touched the top or not. Then I replace that piece of paper, and reverse the process, marking the foot I was previously holding. The reason for doing it this way is so that the two feet are brought into alignment with each other, and the reading made is much more accurate than that taken by just pushing down on the top of the bridge.

Be extra careful from this point on to cut only where the pencil imprint is made, and before cutting anything do a visual check to make sure your eyes tell you the same thing the pencil marks indicate. Work slowly and carefully, and make each cut count. Within a short time you should have a nearly perfect fit. Again, don't forget to constantly check the back-tilt of the bridge, or you may find yourself with a beautiful fit on a strangely standing bridge. A tiny bit of correction can be planed in with the final thicknessing of the bridge by taking more off the front or the back, but not much.

When you are in the final fitting stages you may find it helpful to scrape instead of cutting to fit the feet. This can work well if you're less skilled with the knife, but only use it for small corrections, since scraping can make a mess of things in a hurry. It's good for nipping off a little spot you can't quite get with the knife, or a bump in the middle of the foot. I usually go back to the knife after any scraping because a knife cut leaves a cleaner fit. The fit needs to be perfect, and especially, it should be tight around the edges of the feet: no gaps should be visible. Cutting the feet just a hair hollow may help get the edges down tight; if you don't tell anyone, I won't, but when I say "a hair", I mean it.

On cellos there are a couple of extra points to consider. First, cello legs spread under string pressure and over time. To fit the feet so that they will stay fit, it's necessary to spread the feet with a piece of wood (I use old violin posts) as much as you can manage without breaking a leg. The prop, which is placed down near the bridge's ankles, shouldn't twist the feet, so plane the bridge to thickness first, making sure with a rule that the feet aren't twisted relative to each other. When the prop is in, adjust it so that the feet are again not twisted. This prop is left in until the final string height is set, just before the final carving. Another consideration on cellos is that under tension the arch usually collapses slightly towards the board, so the bridge should be cut standing with a couple of degrees more back-tilted than a violin bridge. Finally, on cellos the post will distort the arch upwards slightly when the string tension is on, so the back of the foot facing the post should be fit just a bit loose to account for this eventuality.

Setting String Heights

Having finished the bottom of the bridge, the top is next. Hold the bridge in position on the top, and place a steel rule on the fingerboard, sliding it down until the corner of the rule touches the bridge. Carefully slide the rule sideways over the top of the board, keeping it aligned with the direction the strings will eventually take, and use the lower corner of the rule to scratch a line on the face of the bridge to represent the projection of the top of the board at the bridge position. Then measure and mark up from that baseline the appropriate string heights for the outside strings, which are 3.5mm and 5.5mm. However, since these heights are measured at the end of the board, not the bridge, it's necessary to add a bit, so use 4mm and 6mm for a start. Next use the bridge template to draw the top of the bridge through these marks with a pencil, and put the bridge back in place on the top. Sight the bridge down the board through the appropriate string's notch in the nut, and placing a rule at the end of the board, check to see if your marks on the bridge will give the right string height. If not, adjust your template line until it appears right. Another way to do this is to use a pencil instead of a rule, in which case the line drawn on the bridge will represent a 3.0mm string height across the bridge. Add height appropriately and redraw the line with your template.

If you do this exactly right, this line may suffice, but chances are that it won’t, and there might be a small error. It's best to give yourself room for error, so trim the extra off the top of the bridge about 1mm over the line you've made. Then string up the violin, put the bridge exactly in place (and check often through this process to make sure it hasn't moved!), tune everything up, and using the template as a guide for the spacing of the outer strings, file the string grooves down through the bridge until the outer two string heights are correct. The string heights are measured to the center of the string, and the grooves need to be not only the correct distance apart, but also positioned so that the strings travel centered down the board, with the same amount of board overhang at each side. Adjust this while filing the heights (by filing sideways as well as down). You can do this by eye, and check it by using a rule to measure in from the board edge to the string. Because of the board curvature, the easiest way to do it is by holding the rule against the end of the board, exactly parallel to the ribs, not by measuring on the top of the rounded board. While the strings are one, check the afterlength distance between bridge and tailpiece to see if it’s the correct 55mm, and note what change you might want to make later before you permanently string up the violin. When the string heights and centering are set, you can loosen the strings and remove the bridge. By placing a pad under the tailpiece to keep the top from getting scratched, you can leave the strings and tailpiece on the instrument from this point on.

With the two outer strings properly set, place the template on the front of the bridge, and remembering that you'll want to not leave too much of a groove for the string to sit in, redraw your line for the bridge arch. File the top down to it, checking it constantly against the template. Do not file off the extreme ends of the arch too much, at the upper corners of the bridge. It's better to leave these above the line of the template, for sharp shoulders, than to cut them off too much and make a bridge that appears to have poor posture. Because the top of the bridge is still overly thick, make sure your filing is square to the bridge by checking it from the side. I do this filing by holding the bridge onto my bench top, with the top overhanging the edge.

Shaping the Thickness

Now it's time to adjust the thickness of the top of the bridge, and blend that into the rest of the body. Though people usually refer to a shell shape on the front (board) side, and a flat back, both sides of the bridge are actually arched, the back so little that you might not have noticed it. Thinking back to the initial thicknessing of the base, we're now going to do essentially the same to the top, planing 1/3 off the back of the bridge and 2/3 off the front, but in such a way that both faces of the bridge are slightly arched from side to side rather than flat. Because of the tapering of the bridge towards the corners (notice that right now the center is thinner than the corners, because the corners are farther down into the wedged thickness of the bridge), this curvature will occur naturally across the bridge, however from the top to bottom it will have to be carefully and intentionally sculpted to be nearly flat.

There are a couple of problems in doing this, both visual and structural. First, it's necessary that the line of the top of the bridge travel in a straight path from one side to the other. If you look at the bridge now, you'll see that viewed from the side the front and back lines of the top edge are both concave. This is easy to see from the top, too. You'll also notice that the E-string side, having been cut down farther towards the thicker bottom of the bridge, is slightly thicker than the G side. In planing the faces, it will be necessary to do so in a way that the thinning happens slightly more from the front, more from the corners than the center, and more on the E side than the G, in order to make a straight top. This is referred to as a “(sea)shell” shape when talking about bridges.

You will read some sources that say that you should make the back of the bridge flat. There are several reasons not to do this, and one is that if you make the bridge flat on the back, you can be assured that the bridge will warp backwards; I have not seen a single bridge with a flat back which has not become concave on the back after several years. The forward pull of the strings will not compensate for this—I have seen many bridges which are S-shaped—bending forward at the waist, and backwards in the upper section because the back was flat. The cross-section of a bridge with a flat back is somewhat like that of a banana—squeeze it from the ends and there is only one way it can bend. Tonally, you will eventually find that this is not the best way, also. I believe this is because if both sides are shelled the line of the movement of the bridge is through the center, but if the back is flat, the movement is as if you were pushing a wagon by the back corner; that is, turning, not directly straight, which sets up an undesirable movement in the bridge.

There is one additional consideration, and that is that perfectly flat surfaces tend to look concave. So in order to have a bridge that looks strong rather than hollow-chested and weak, it will be necessary to leave just a bit of convexity in the vertical aspect of the faces, but not enough to be obvious, and evenly distributed, not localized in one area. A common error to be avoided is to keep the original thickness through most of the height of the bridge and do the thinning only near the top. To make the top edge look strong, you should do the opposite, and make the top 5mm or so of the faces particularly flat and crisp, and avoid rounding this in any subsequent sanding.

Finally, at the corners of the edges on the sides of the bridge it will be necessary to keep those lines that make the edge corners very slightly convex, but only to the extent that the lines appear straight. (Only a check against a straightedge reveals the curvature). This is a complex concept, but perhaps after you get into it you'll understand better.

I begin the planing the contour above by thinking of the bridge as having three flat panels made by drawing lines from the center of the top edge diagonally down to the tips of the knees on the outside edge, for a start, and plane those panels in on each side with an eye to refining the top to the line I want, viewed from both the top and from either side. Then, after the panels are established, I blend them together. Viewed from either side, the results should be a natural stance, not exaggerated in any way. The ideal result is shown in the illustrations. When planing either side of the bridge, be especially careful of the little dollop hanging in the center of the heart. If you plane this from side-to-side or down towards the bottom of the bridge, you run a strong risk of breaking it off—always this tiny part upwards, so you are pushing it against its supporting stem instead of bending (and breaking) it off into space. Initially work the top down to around 1.5mm or so, and take the last couple of tenths off paying careful attention to both the straightness of the top as viewed from above and from the ends, and making the thickness of the top edge completely even from corner to corner.

Place a piece of 220-grit sandpaper on a hard, flat surface, such as a clipboard, and lightly sand both sides of the bridge by pressing it down on the paper and rubbing it carefully back and forth, taking care to smooth and blend all areas. This completes the sculpting of the front and back. The next process shapes the cut-outs of the bridge from their roughly cut original form to give the bridge a completed, more elegant look.

Shaping the Bridge

All of the detail carving of the bridge is done using the smallest possible knife. I use a 3mm laminated Japanese knife. Another excellent idea, which I've intended to test but never have, came from a shadowbox I saw in the Hill shop, filled with W.E. Hill’s hand-cut bridges, and his knife, which appeared to be a common awl with it's round blade sharpened like a knife towards the end. I believe the whole thing was about three and a half inches long, including the handle. Again, it's better to have a knife with an edge that is convex, rather than straight.

The 3mm knife is quite difficult to sharpen correctly. You can start on the hand grinder using the tool rest and finish by hand on stones. Perhaps because of the small amount of steel involved, I often find that the edge is defective in some undefinable way, and it takes more honing on this one than on other blades to remove a layer of disturbed steel at the edge and get an edge that cuts well. I don’t have much advice other than to keep honing until the knife works well. As on all of the knives that do this type of work, the curve on the edge is essential for accurate carving, allowing you to pick out spots you need to cut while leaving adjacent ones untouched.

The previous parts of this job haven't required a lot of aesthetic taste--anyone can follow the steps and come out with something that's more or less right. The rest of the job is where aesthetics come in. There are both tonal and aesthetic issues in carving the shape of the bridge. The tonal things are a function of the location of weight, and of the flexibility that comes from thinning strength points. Wood that is out of the path of support--on the arms, for instance, dampens vibrations to various degrees. The thickness of the waist and the legs determines strength and flexibility. Fortunately, the shapes and dimensions of these things are closely defined as a result of a couple of centuries of testing, and they don't vary a whole lot in basic size. However, the shapes involved are flexible enough to allow bridges to be cut with many different appearances, which is really the fun of the whole thing.

There's a really excellent website which has illustrations and measurements of hundreds of bridges, and it's a good source for visual ideas: http://violinbridges.co.uk. It's useful to go there and look at a lot of bridges to get a sense of the possibilities, and to note the narrow range of dimension of critical areas.

Basically, shaping the bridge involves the following:

- thickness and shapes of the feet,
- width and shapes of the ankles,
- shape and height of the arch over the feet,
- height and shapes of the legs,
- shape of the kidneys, and their size,
- shape and size of the kidney spurs,
- shape and size of the heart,
- three-dimensional cutting of the spurs and the dangly part of the heart,
- bevels on the edges,
- final contour of the top, and the cutting of bee stings.

Most simply, this comes down to the shapes of the feet and ankles, and the white space around them, and the shapes of the kidneys.

The unsupported ends of the feet should be about 1mm in thickness, the same size, and similar in style, mirroring the inner tips of the feet and the spurs of the kidneys. The spurs above the toes of the feet should also mimic this shape and size. The cutout on the outside of the angle should be a clean and definite shape, and often this is a section of a circle, or in some cases slightly parabolic, but always bump-free (and hold that concept throughout this process).

The equivalent area on the inside of the ankles is part of the arch across the middle, and should blend smoothly with it. There are several ways to do this, depending on the style of arch one is cutting, but the curve into the insides of the feet should be attractive, and smooth. I make this arch somewhat similar to the arc of the top of the bridge and of the top of the violin, but less than either one, and relatively low.

Kidneys are usually cut in one of two styles--egg-shaped, or slightly squared on the outer ends. Again, the goal should be a smooth flow from the knees to the end of the spur, a definite shape, lump-free, and attractive. All four views (front and back of each kidney) should be identical. Look at different professionally-cut bridges until you can see what you're looking at, then when you find something you like, try to copy it.

I just clean up the shape of the heart until it's smooth, without changing much.

All cuts should be clean all the way through the thickness of the bridge. Don't just cut the part you see from the outside, and leave the middle rough. Make everything that's supposed to be the same (all the feet, both spurs, etc.) really the same. When you think you're through, it's best to leave it overnight, and when you come back the next morning with fresh eyes you'll see more bumps and inconsistencies. Do the very best job you can do--a repairman's bridge is the only thing on a violin that's his, and his alone.

The easy parts of the bridge to cut are the outsides of the feet, so I usually start there to warm up, trimming the outside toes to about one millimeter high, and the same for the spur above them. Between these, the c-shaped ankle cut on the outside should be shaped to a perfect semi-circle. The tips of the toes and spurs should be just a bit thicker, to give a nice lift and a bit of life to the end of the cuts, and the circular shape should be as clean and true as you can make it.

Next, I work on the points in the kidneys (attack these from their ends, cutting inwards on them, and you won't have anything chip out where you don't want it to), making them have the same general shape and height as the parts of the feet that I've already carved. Before shaping them, though, taper each one in from both sides of the face of the bridge, to a sharp point. Then continue on, shaping the kidneys. My intent there is a smooth and gracefully curving line from the knees of the bridge inwards from the outside of the bridge, around the kidneys, to the tip I've just shaped. The shape of the kidney is highly personal, but whatever is done should be neat and elegant, not the indefinite hole the blank came with.

When they kidneys are done, I shape the heart area, maybe only cleaning up the curves, or opening it up more if I have tonal reasons to do so. Before doing this, the fragile dollop at the center of the heart should be cut back from the face of the bridge on each side similarly to the points in the kidneys, but only enough so it won't catch on something and break off. Be extremely careful, or you'll be the one breaking it off! This gives you a bit of additional clearance when refining the heart.

Last, I carve the most difficult area--the insides of the feet and the arch under the middle. This, again, should be a continuous graceful line that makes visual sense and mirrors some of the other features of the bridge. It's OK to use a tiny round nut file in the ankles —cutting this tight spot is hard to do with a knife. As with the outside of the feet, the thinnest spot should be just in from the tip, and the thickness should be ample—about one millimeter high.

Cut the remaining two string notches, pacing them off with a dividers so each string is equally spaced. String grooves should be 1/3 the diameter of the string deep at the most, so don't get carried away. They'll only get deeper in the future.

The top of the bridge is rounded, but not into the faces--a crisp line is left there. This is done by filing off each edge as a long facet from one corner to the other, at about a 30-degree angle, on both sides of the bridge, and then lightly sanding (400-grit) off the two little points on the top formed by the facets without touching the outer edges between the top and the face, so that the top, viewed from the side is slightly domed, looking a lot like the top of the bridge when viewed from the front or the back. Make sure this dome is especially perfect at the ends, where you get to see it in cross-section.

The small bee stings above the feet are just pressed in with the tip of the knife—they aren't actually cuts. Make them in line with what's already happening there so that they are continuations of already-established lines and the spurs are the same size and shape as the toes of the feet. There are four bevels on the straight corners of the edge of the bridge. These start at the top as nothing, and gradually widen towards the bottom, as a straight-sided triangle. I do this with a file, and make the bevel on the front side of the bridge slightly larger than the one on the back. The macho way to do this is with a knife. The remaining flat edge on the side of the bride should be the same width from top to bottom: the width of the top of the bridge--that is, about 1.3mm or so.

To finish the flat faces, put a sheet of 220 sandpaper on a flat surface (I use a clipboard) and sand both sides lightly, then do the same, with 400 sandpaper. Do the edges with 400, also. It's even better if you can skip the 220 and go directly from a scraper to 320 and 400 grits. Excessive sanding rounds the edges of surfaces that should really be crisply flat.

The final steps are staining the bridge and putting a skin under the E string. I spray a stain made of drafting inks with my airbrush, and sometimes I will also dip the bridge in very dilute shellac, wiping off the extra. Then buff the bridge’s faces on a piece of cloth that’s flat on your clipboard. The protective skin for under the E string is cut to about 4.5 X 9.0mm, the corners nipped off at 45 degrees, and glued on with super glue. Moisten the skin in your mouth until it’s soft enough to wrap on the bridge easily and pull into the string groove. Violin supply places sell little pieces of skin cut to the right dimensions, or you can make your own by cutting them from a piece of thin natural drum head, if you can find the right material. Lube the founr string notches with a pencil, and you’re done.

Therapeutic Bridges

When cutting bridges for new violins, things like the arch and neck set should be perfect, because that's how you made them. A normal bridge, as above, should fit just fine.

Old violins pose various problems. The arching will almost certainly be collapsed towards the bass side, tilting the bridge in that direction. The neck may not be aimed down the center of the instrument, the f-holes may not be in the center of the instrument. The previous positions of bridge, post, and bassbar may have been based on something that you can't now figure out, or perhaps there was no sense to them in the first place.

Before you fit the bridge, you should first try to figure out what the previous person thought was right, and whether you agree. You may discover that you want to map out a whole different string path, adjust the board, move the end button, and put the bridge in a different spot. You may discover that getting everything in line is impossible within the allowed budget, and eventually you may decide to put on a bridge that minimizes errors by standing crooked in some way or another. That's what this section is about.

Before doing a setup on an old violin, I measure the neck set by the same technique I used when making the violin, and check the bridge and end button centering. I then decide if anything needs to be moved to center things up. There are many different ways to do this, all of which may be equally good. Ideally, the strings should be running in a straight line down the center of the instrument. The last thing to give up on is the straight line. They can be running diagonally across the body, over to one side, but they should be running straight. What I usually do is try to figure out where the fingerboard is pointed, see if that happens to be at the end button, and then hope that this all runs reasonably close to midway between the f-holes at the bridge position. If It demands a bridge that's left or right, I'll do that, but many people expect the bridge to be centered, and there may be strong footprints on the top at that point, even if it's wrong. It's possible to build a bridge that stands centered on the f-holes, but stands tilted so that it's also centered on the board's projection. The best circumstance is if everything is centered, but when you put a bridge on, the top seems to be off center—that can happen because of the sinking of the top on the G side, mentioned above.

No matter what you decide, you may need to fit a lopsided bridge. There are five ways to accomplish that, and each is good for moving the string path about 0.5mm sideways:

- Cutting more off one foot than the other in fitting the feet, tipping the bridge to be in line with the board (good for when the top arch is crooked)
- Laying the strings off-center on the top of the bridge
- Planing the sides of the bridge differently, taking more off the top on one side than the other
- Sacrificing bridge centering on the top
- Sacrificing string centering on the board.

Basic Bridge Tonal Adjustments

There's a lot of noise around about “tuning” bridges, however, some interesting research on bridge tuning showed that good bridges from good shops are all tuned in about the same way. This is not intentional. Effective bridge shape has a long historical background before modern technology: it's the result of using tested and proven parameters and dimensions that have been shown to work well. Follow the rules, and the tuning will follow.

As remedial treatment, though, there are things you can do to bridges to change a violin’s sound. I like to get to know a violin first with the bridge it comes into my shop with, decide how I want to change the sound, and then look at the original bridge and see what I’d change to accomplish what I want to hear. If I’m starting from scratch, I start with small cuttings and extra thickness, and gradually change and thin until I get what I want, though now I can usually guess what a particular violin will want by looking at the arch and model, and go there directly, without too much experimenting.

In general, here are a couple of easy rules: the thicker a bridge top is, (and up to about 1.6mm is practical, with around 1.2mm the minimum), the more muted the sound; as it’s thinned, the sound becomes less muted, but noisier, and finally the sound will have too much noise and not enough music. Violins with a nasty quality tend to want a thicker top on the bridge. The bottom of the bridge mutes volume until it's the right thinness, and past that nothing changes, except that the bridge becomes thinner and weaker. Usually the cutoff is at around 4.2mm. The thicker the middle, waist and slightly above it, the more nasal the sound. A certain amount of that is desirable, or the tone may be read as “too open” but too much thickness here is just read as “nasal”. Other parameters to play with are the size of the kidneys, and the height and shape of the arch under the feet. In general, the kidneys shouldn't be cut above the bottom of the heart. I also do my best not to narrow the waist between the kidneys, which usually affects the sound adversely. Most makers feel that 15.5mm is needed here, at a minimum, and just cleaning up the kidney shapes will get you near that very quickly. Some makers have definite feelings about the size of the arched space between the feet, but I don't have strong opinions on that, myself.

Choosing and Fitting Tail Pieces, Afterlength, and Tuners

The tailpiece is not the incidental part of the violin that it may appear. The dimensions and placement are critical to the sound of the instrument, and materials, shape, and weight also have effects. It works in conjunction with the afterlength to modify the tonal quality of the instrument, and inappropriate tuners can be detrimental.

The rule usually cited is that the afterlength of the G string should be 1/6 of the total string length, on any instrument. On the violin this is usually taken to be 54.5mm in some standards, and 55-57mm is what I was taught, to account for stretching of the tail gut over time. This is a reasonable starting point.

Other general rules are that for violin the tailpiece should have as wide of a string placement as possible, that it should entirely fill the space between the afterlength and the saddle, and that the tail gut should be as stiff and widely placed on the saddle as possible. For violas and cellos the opposites apply. Additionally, many violas function better when the underside of the tailpiece has been hollowed out to a thin shell. Cellos function better with plastic or metal tail pieces of various kinds rather than wood.

On violins, only one tuner, on the E, is best, and it should be the short Hill style with a finger that peeps up from the string slot. The fingers on these are pressed out, and sharp on one edge. Round the back of the hook where it holds the string with a file to remove any sharp edges that will break the string. Melt a bit of candle wax into the adjustment screw hole, and onto the screw, for lubrication. For violas, one finger hook tuner is all right, but if you want tuners on your cello, use a tailpiece with them already integrally fitted. The extra weight of four large metal tuners is always very detrimental to the sound of any violin family instrument, so avoid that at all costs.

More specifics about tail piece adjustments are discussed in the adjustment section.

Fitting the Saddle

The saddle gets fit after varnishing so that ebony dust will not be pushed into the bare wood of the top. First the true center of the bottom of the top is located, and points struck off 17mm on each side (for a total saddle length of 34mm). Saw cuts are made on these points, squarely into the purfling, and almost through it. Cut as close to the rib as possible, but don't touch it with the saw.

The saddle will replace the purfling, which will be cut out, and the line behind the purfling straightened to fit a straight saddle. Place a rule on the top between the back of the purfling where the end cuts intersect, and score a straight line between these points for the straight line of the inside of the saddle (nearest the tailpiece). Deepen this cut, and then chop out all the wood where the saddle will go gradually with a knife, making all the edges perpendicular.

Take a saddle blank and saw it to length. You can saw it just a bit long, and trim the ends cleanly with a file or knife so that there's about 0.5mm of looseness at each end of the saddle. This is to keep saddle cracks from developing when the top shrinks and the saddle does not.

Plane the bottom of the saddle flat, then the inside edge so that it fits well against the end grain of the top without any gaps, seen or unseen. Next plane a 45-degree bevel up from the inner junction of the top and the saddle for the rise of the saddle above the top. Finally cut the two ramps at the end of the saddle using a knife. These should be about 8mm long, and by the time they are to the level where they join the top they should match perfectly the height and angle of the scoop where they end. The last cut should be with one clean knife cut, and it shouldn't be necessary to clean up this surface with scrapers, files, or sandpaper if your knife is sharp. At this point, glue the saddle in place, finishing the exterior, rounded surface after the glue dries. Use hide glue, liberally applied to the hole cut for the saddle, and pre-heat the saddle over an alcohol lamp until it's too hot to touch (use forceps), then place it in location and push it home, holding it there for a few seconds. The heat should partially set the glue immediately, but let it dry for ano hour or two before working the outside.

Finally the outside contours are shaped with a small plane, files, and sandpaper until the saddle is simply a continuation of the shape of the edge, sanded to at least 400-grit. You may want to mask the edge on either side with a bit of masking tape to avoid disturbing the varnish. When you look at the saddle from the tail piece's viewpoint and then roll the violin up so you gradually see more and more of the edge, the saddle should be a graceful shape all the way, quickly disappearing into the silhouette of the edge, not sitting there as a lump sticking up.

Fitting the End Button

The end button of a violin or viola is shaped to the second hole in the shaper (the size of the top of a viola peg shaft), and the hole reamed to fit. The hole must be located on the calculated center of the bottom of the instrument, not simply on the rib seam, and should be tilted back slightly so that pull from the tailgut will pull it towards straight rather than away. If it becomes tilted up at all the collar against the rib will receive all of the force and break. I usually place the hole slightly low on the rib because subsequent top removals will result in a gradual lowering of the rib. Again, the principle here, as with the end button's tilt and the location of the ends of the pegs, is that any future wear will result in pieces moving into adjustment rather than immediately out of adjustment.

Commercial end button holders are available and desirable. I made mine from a strip of wood with two different size reamed gripping holes and a slit for adjustment, carried out by a nut and bolt (illustrated).

Stringing Up

The last thing to do is put on the strings. I start by putting on the G string, because it's the first peg whose string hole is covered by subsequent strings. As soon as that one is on, I prop up the bridge in place, or pack a folded paper towel under the tailpiece so that the tuner won't scratch the top. Then I put on the E, D, and A in that order. Strings should go on neatly, by first winding a couple of turns towards the small end of the peg, then crossing the string back quickly over those wraps, and wrapping neatly towards the peg head until the string is up to pitch. The last wrap of string shouldn't touch the inside of the peg box, and it's important that the last two turns aren't part of the cross-over because the stress of one recent wrap over another will break the string sooner. Make the wraps neat and pressed together by pulling the peg out and packing the windings just before the last turn.

It's not important to turn the strings up slowly, but you do want to keep an eye on the bridge to make sure it doesn't pull forward and fall down. Also make sure it's ending up it the right place because it's a lot harder to move around after the strings are up to pitch. The E should always be the last one to go to full pitch because it's the weakest. Tuning up the G pulls the tailpiece towards the G side, and if the E is fully tuned this little extra pull can overstress and break the string. Likewise, when letting strings down, always tune the E down a bit first.

Both the tail gut and the strings will stretch a lot initially, so keep an eye on the tilt of the bridge—it will be moving towards falling down, constantly during the stretching process and has to be pulled back frequently.