

How To Build A Classic Workbench



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1 Overview Of The Classic Workbench

If you want to start your own woodworking journey, you need a workbench.

A good and classic workbench will last you for generations.

This write up includes plans, a materials list, cut list, diagrams, color photos, and lots of tips step by step instructions along the way.

Best of all, this workbench won't cost you much money.

Detailed drawings can be found at the appendix.

Before we start, here are some detailed photos of the finished build





Shoulder vice end cap



Tail vice front view



Tail vice dovetail and handle



Tail vice end cap and rear view



Tool tray dovetails

2 Sourcing and Rough Cutting the Wood

Below is an estimate showing the amount of wood required for each piece (using approximate dimensions).

Estimate

	Dimensions in Inches			BF	\$/BF
	L	W	D		
Top 3" thick section (8/4)	89.5	16.5	3	30.8	5.95
Top 4" thick doghole strip (8/4)	93	5.4	4	13.9	5.95
End caps & vice arm (8/4)	94.1	3.25	4	8.5	5.95
Shoulder vice spacer (8/4)	8.5	6.25	2.75	1.0	5.95
Tool tray back board (5/4)	95.0	1	4	2.6	4.95
Base #1 top and bottom arms (8/4)	72.5	3	4	6.0	5.95
Bases #1 & #2 cross brace (8/4)	32.5	1.5	2.5	0.8	5.95
Base #1 vice leg (8/4)	30.5	2.25	2	1.0	5.95
Bases #1 & #2 main legs (8/4)	122.5	3.5	2.75	8.2	5.95
Base #2 top and bottom arms (8/4)	54.5	3	4	4.5	5.95
Stretchers (8/4)	256	1.75	4	12.4	5.95
Spacers under bench (5/4)	46	3	1	1.0	4.95
Off cuts & waste (8/4)				89.2	5.95
Tool tray bottom (1/2" maple ply)					
Veneer for tool tray ramps					
1 gallon white glue					
Scandinavian vice screw and handle					
Small welded tail vice and handle					
Wooden bench dogs					
Lee valley bench bolts					
Lee valley bed bolts					
Leveller feet					
5/8" threaded rod					
Stainless #14 screws					
1 1/8" dowel for new handle					
Insert screws for new handle					
Finishing supplies					
Sub total					
GST (sales tax @ 7%)					
Grand Total					
Total board feet				180	

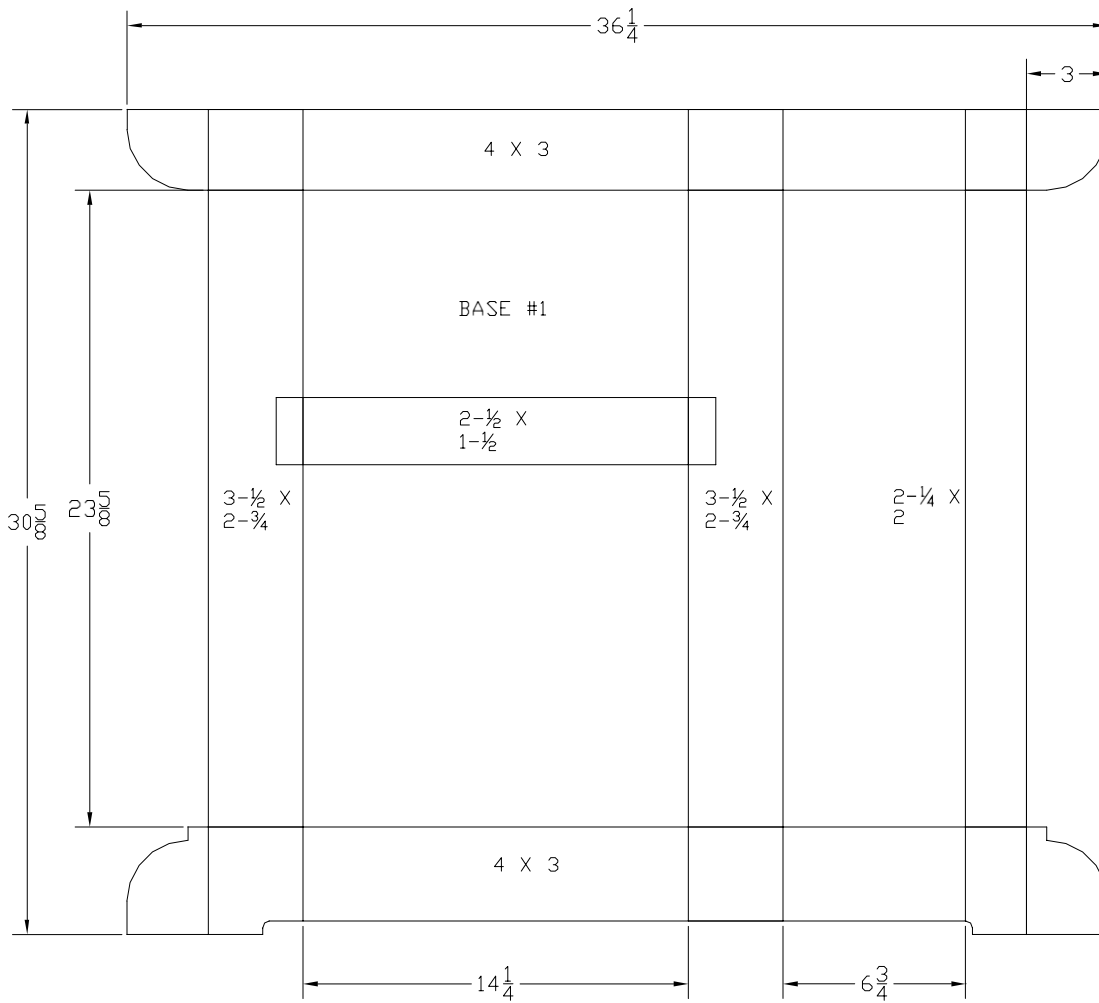
Now is the time to develop a fairly detailed design. Planning ahead allows you to rough cut your wood in a non wasteful manner.

Each bench is slightly different due to the dimensions of the wood you start with and the particular hardware you choose, so I highly recommend that you make a detailed set of plans for yourself as well.

3 Building the Bases

Next I turned my attention to building the bases. Every piece except for the cross braces was made up by laminating two 8/4 boards together. I jointed all of my stock using hand planes, so this was a heck of a lot of hand planing.

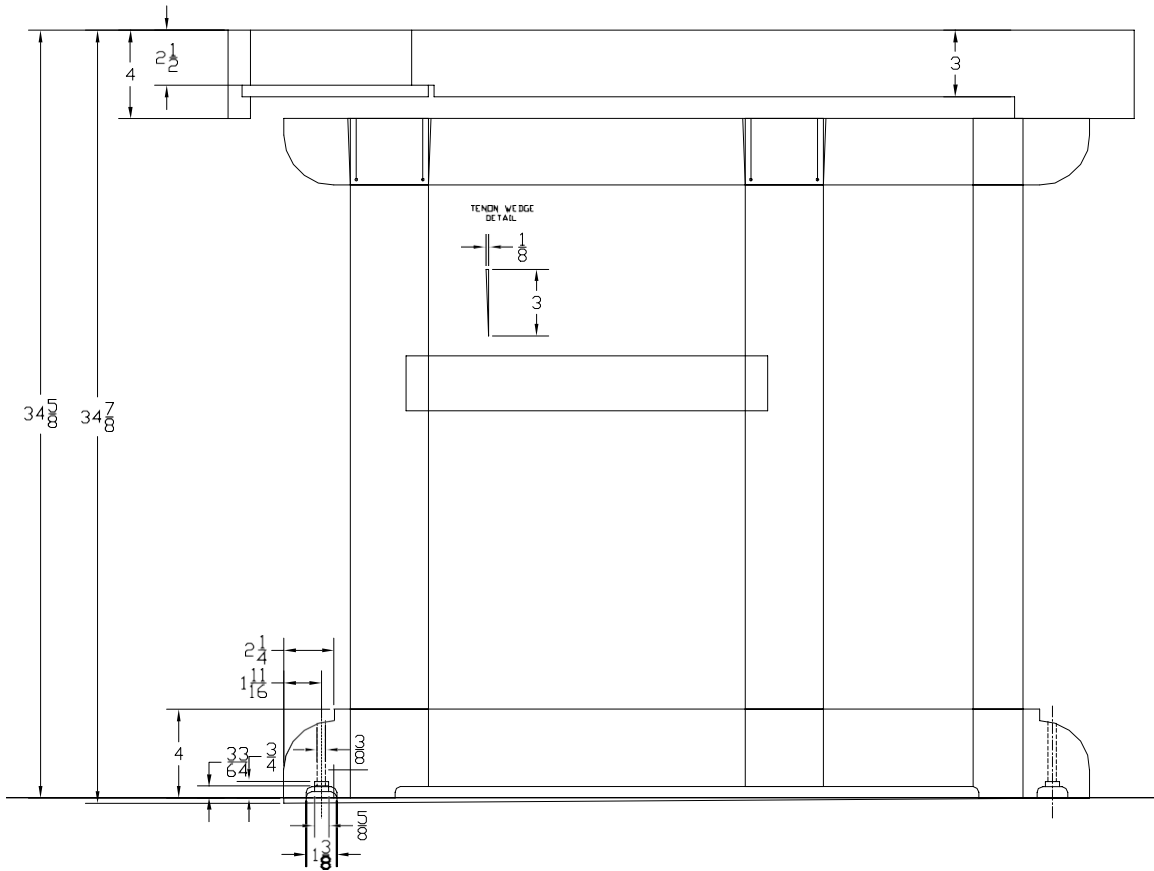
If I was to build this bench again, I might take the trouble to get hold of 12/4 stock. This would have significantly cut the amount of work required. Using the 8/4 stock I was forced to dimension two pieces, laminate them together, then dimension the finished piece.



. General Dimensions of Shoulder Vice End Base

The following drawing shows the shoulder vice end base including the bench top. The front end of the bench top was 4" thick, while the remainder of the bench top was 3" thick.

This makes the top of this bench $34\frac{5}{8}$ " off the ground – slightly higher than recommended by some, but it feels comfortable for me (I'm 5' 10" tall). A 1" high spacer block, not shown in the drawing, fills the gap between the top of the base and the 3" thick section of the bench top.



General Dimensions, including bench top thickness (front of bench is to the right)



Dimensioned stock for bases

After dimensioning the wood, I joined the pieces using through wedged mortise and tenons.

After laying out the joinery I drilled a single pilot hole in the middle of the mortise. This gave the chips somewhere to go and let me drive the chisel more deeply than if there were no pilot hole. The perpendicular pencil lines drawn on the mortise were a crutch to keep my chisel square to the cut.



Chopping Mortises drilling pilot hole

Second, I chopped towards one end, stopping just short of the end. I cleaned up the last 2 or 3 mm of the mortise after I had hogged out most of the waste.



Chopping mortises – half done

Next I chop to the other end. I had to make several passes to get a mortise 2 3" deep. Once I was at the final depth, I chopped the ends of the mortise square and double checked to verify that the sides and ends were parallel and square:



Chopping mortises checking to see if ends and sides are square

This method went pretty quick. I think the pilot hole makes chopping mortises a lot easier, and there are lots of mortises in a workbench base:



Chopping mortises – done!

The tenons were roughed out on the table saw using a tenon jig. They were too large to cut with my tenon handsaw.

As a matter of fact, they were too big for my table saw. I finished off cutting the tenons using a panel saw, and then fine tuned the fit with a shoulder plane. This would have been a perfect job for a band saw if I had had one at the time.



Finishing off the tenons with a handsaw

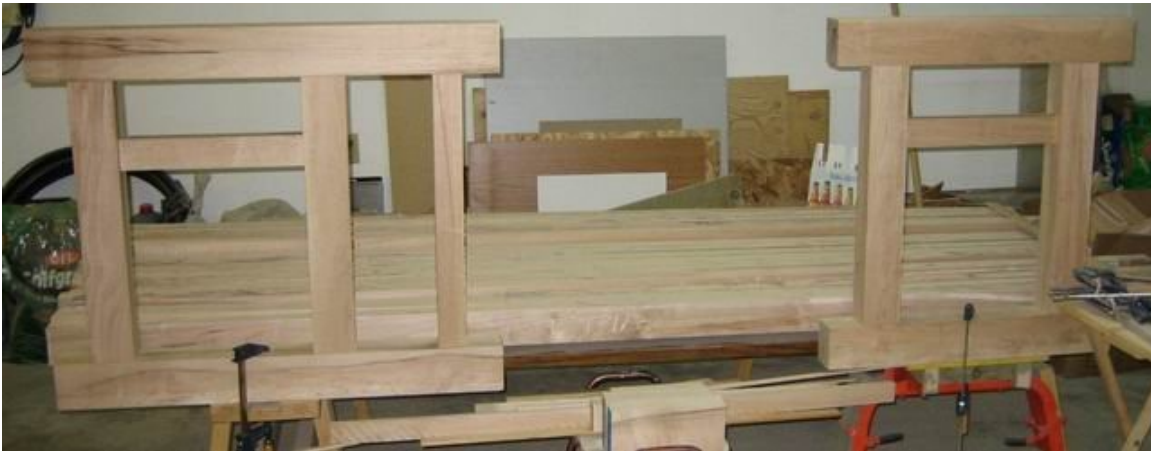
I used wedged mortises on my base, but I don't think they're necessary. With a 4"x3" tenon there is a huge glue surface. In the photo below I haven't cut the space for the wedge into the tenon, but the through mortise is complete.

I cut the angled ends of the mortise using a chisel and a 3 degree guide block. The wedges were cut out of a 1/2" thick cherry board at a 3 degree angle using a taper jig on the tablesaw.



Through tenon showing allowance in mortise for wedges

Here's a picture of the assembled (but not glued) bases:

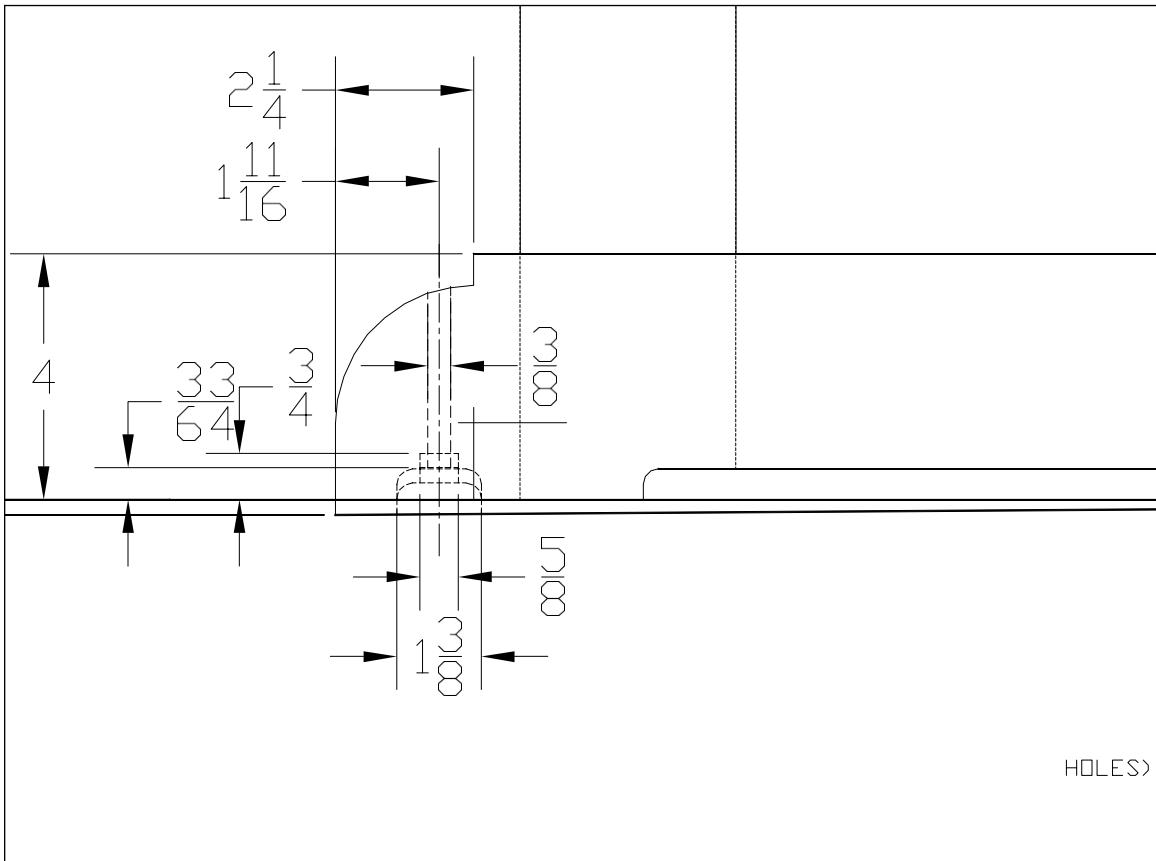


Bases assembled – April 18, 2005

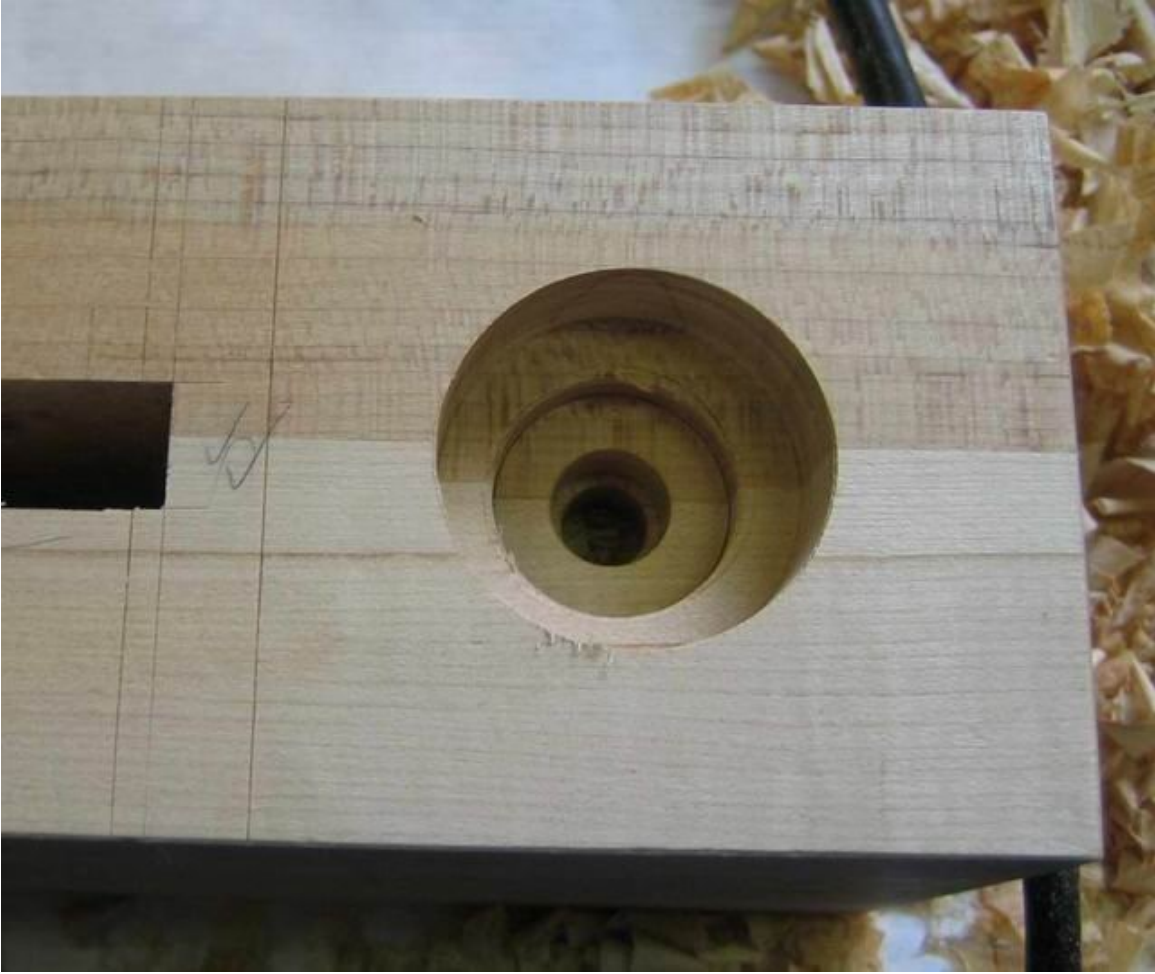
I wanted to incorporate adjustable levelling feet into the bench. Finding appropriate feet was difficult, so I ended up with typical appliance feet; rated at something like 350 lbs each.

I also countersunk the feet into the bench because I wanted a low profile look, and I didn't want the bench to be any higher than I had already designed into the bases (ahem... another reason to plan ahead). After installing the levellers, I cut the threaded rods down so they would be approximately flush with the top of the sled feet.

The following is a drawing detailing installation of the levellers. My garage floor is gently sloped, so I allowed for this slope in the drawing. These holes were drilled freehand but, as with the band saw, I acquired a used drill press part way through this bench project, and I now realize how much easier things would have been if I had the proper tools at the start of the project.



Detail of leveller installation



Holes drilled in underside of foot for leveller



Leveller foot underside

Before gluing up the bases, I cut the profiles on the ends of the sled feet. I did this on the band saw, cleaned up the saw marks using a spokeshave, and then finished up by sanding the end grain to 400 grit smooth as a baby's bottom.



Final shaping of ends of sled feet

After profiling the ends, I trimmed the screw on the leveller feet to be flush with the foot profile. I cut a slot into the top of the screw so that it could be adjusted with a screwdriver. I cut the slot with an angle grinder equipped with a cut off wheel, but a hacksaw would have worked as well.

The last step in completing the sled feed was to cut the recess on the underside of the sled foot. I cut this out on the bandsaw and removed the saw marks with a spokeshave and scrapers.



Completed foot showing leveller adjustment screw

With the feet complete, it was time to glue up the bases. The shoulder vice end base was a bit tricky to glue up because all three vertical legs have to line up perfectly to fit into their mortises.

This is a bit like trying to juggle cats, meanwhile your glue is skinning over. I ended up having to pound mine together, resulting in breaking my cheap mallet. This was a good excuse to go to Lee Valley and buy a good mallet. Luckily that metal cylinder didn't go flying across the room when I was pounding the base together.



Broken mallet doesn't pay to buy cheap (or at least you shouldn't pound on a cheap mallet too hard).

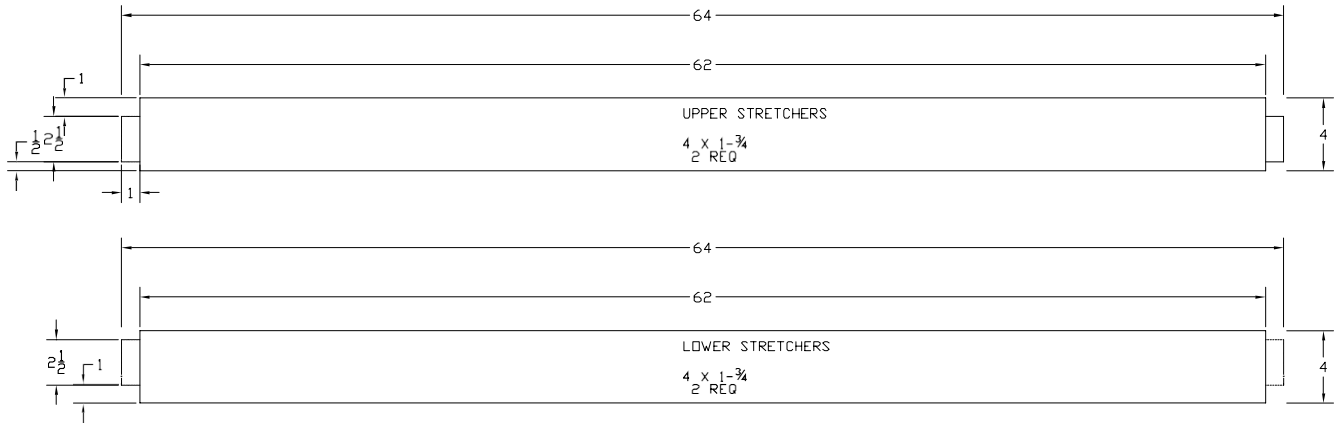
4 Stretchers

With the bases assembled, the stretchers were the next pieces to be made. I selected the worst boards for the stretchers – thinking they were the least important boards in the bench – but once the finish was applied, these “worst” boards turned out to have some of the nicest figure.

The boards had several splits and checks in them but this didn't hurt their use as stretchers. I filled the splits with epoxy beforehand just to make sure they didn't spread.

Below are drawings of the stretchers. Note that the tenon on the upper stretcher is offset downwards to move the accompanying mortise in the bench leg further away from the end of the leg.

The tenon on the lower stretcher is offset in the opposite direction.



Stretcher dimensions

The first thing I realized when trying to dimension the stretcher boards was that my current bench was inadequate.

The bench was not flat enough along its length to allow me to accurately dimension boards as long as these stretchers. So, I spent a day levelling my plywood bench using a floor jack and a billion shims. A piece of plywood acted as an eight foot long straight edge.

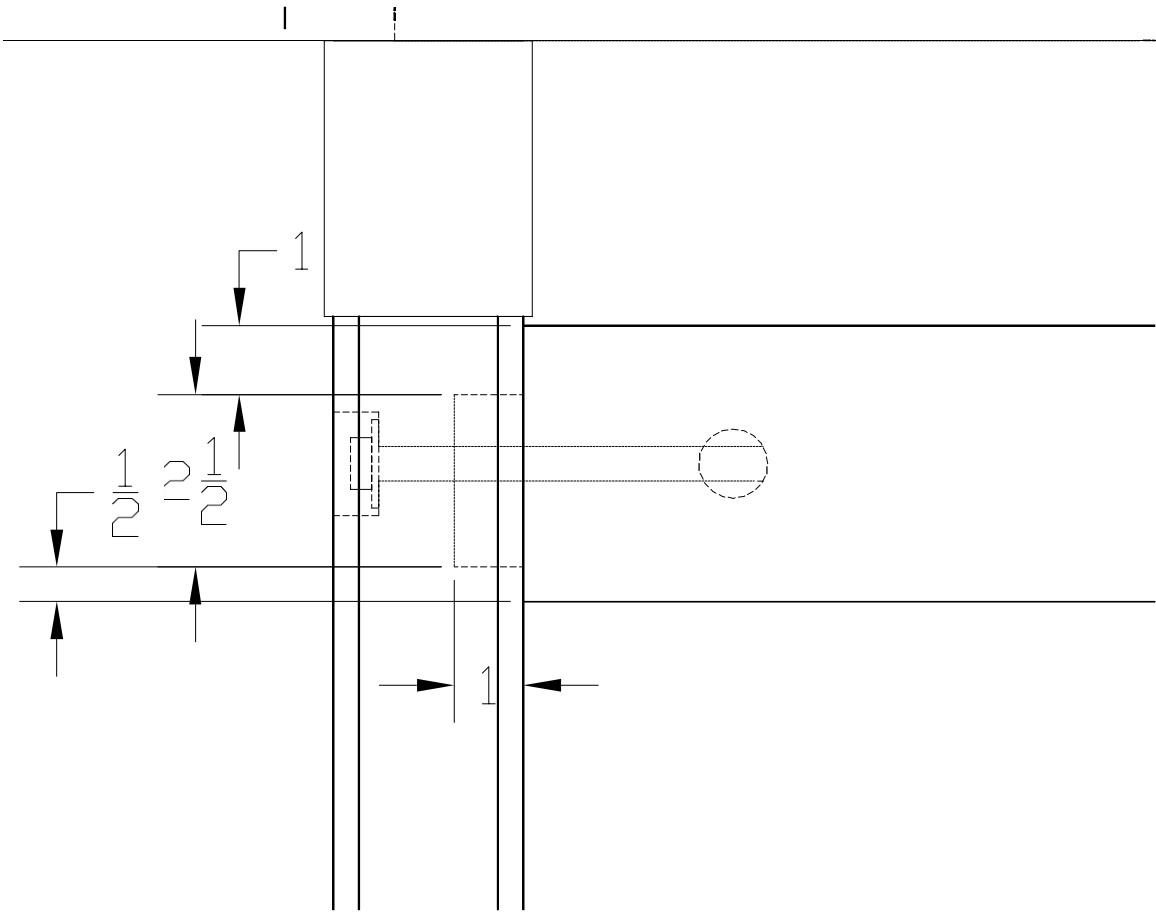
Once the workbench was levelled, dimensioning and cutting the joinery on the stretchers was easy. The stretchers are tenoned into the bases, but the tenons are not glued so that the base can be disassembled if I ever have to move this beast.

I used Lee Valley's bench bolts to hold the stretchers in place. They are a bit expensive, but work great and have a nice clean appearance.

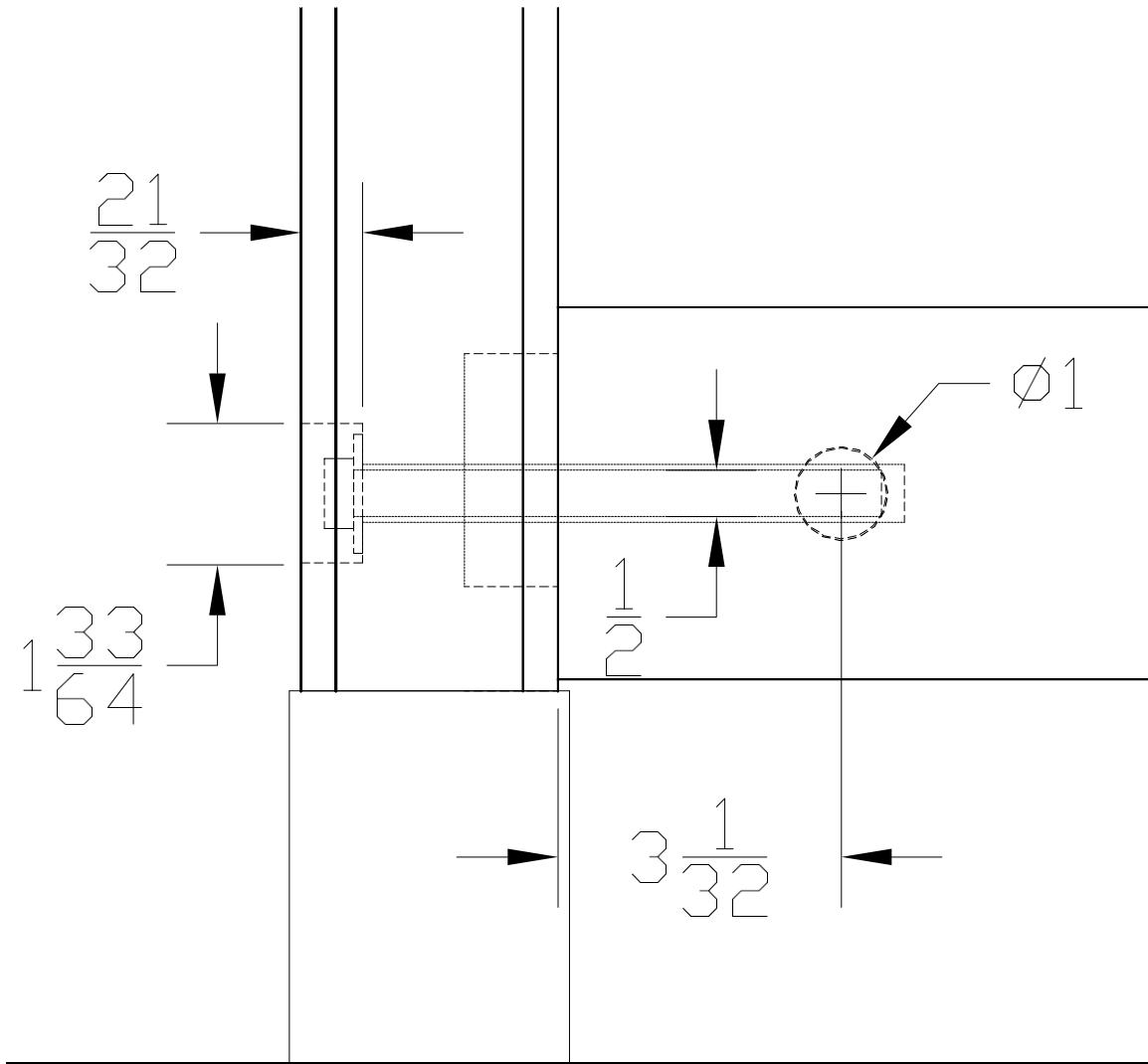


Installing the bolts was another chore that would have been much easier with a drill press. Nevertheless, with careful hand drilling, the installation was almost perfect. Following are some sketches of the bench bolt installations.

As a general comment on all of the sketches, some of the silly dimensions, such as drilling a $1 \frac{33}{64}$ " hole, are not what I actually did. The hole is drawn at $1 \frac{33}{64}$ " because I eyeballed the dimension on the sketch. When constructing the bench, I took a washer, compared the diameter to my available stock of drill bits, and selected the next larger size bit. Instead of drilling a hole $2 \frac{1}{32}$ " deep, I drilled a hole around $\frac{5}{8}$ " deep, then checked to see if the hole was deep enough so that the bolt head was completely recessed, and so on.



Upper stretcher tenon location



Lower stretcher tenon location and bench bolt installation details

Once the stretchers were installed and tightened up, the base was almost complete! The last step was to ensure that the tops of the bases were flat and not twisted relative to each other.

These steps were easy to do with a hand plane and some winding sticks. I noticed that with a non flat floor, it is easy to introduce twist into the base when relocating it. The floor levellers should be used to re level and untwist the base every time the base is moved.

5 Assembling the Benchtop

After a good rest, the real work began – dimensioning the boards for the top. As I said, I face and edge jointed every one of these boards by hand. Luckily breaking my rule of not realizing how much easier some things are if you have the right tool until after the job is done I had already bought a thickness planer.

There was no way I was going to thickness this many maple boards by hand. Jointing the boards by hand was enough work. Each one of the boards was perfectly square and very close to perfectly straight before I started the glue up.

First I laid out the boards with two criteria, in order of importance:

1. First, the grain direction for all boards must be the same! This makes the job of flattening the top much easier at a later date. In addition I wanted to plane from right to left, so the grain direction of all boards was rising right to left.
2. Second, I ordered the boards for a pleasing appearance, with the whitest wood upwards and flaws downwards.

3. One board was narrow enough that it ended up being less than 3" tall. I put this board on the very back of the benchtop, and cut that board to 2 1/2" tall. This resulted in my tool tray only being 2 1/2" deep instead of the 3" that I wanted, but I figured that if 2 1/2" was enough for Frank Klausz, it was probably good enough for me.

Below is a picture of the boards laid out ready for glue up:



Benchtop boards laid out for best grain direction

My glue up strategy was to glue one board at a time. I know some people can glue up all fifteen boards in one shot, but not me.

My plan was to glue the first two boards together, dimension that piece so that it became a nice straight reference, then glue the next piece on and so on. Once I had four boards glued together and dimensioned nice and straight, I had a very strong reference beam which I could use when clamping and gluing future pieces in place.



Gluing up the first course of four boards

This strategy worked very well, and the resulting glue up was very straight, non twisted, and required minimal clean up work. I actually glued up the top into five sections. Each section was three to four boards thick resulting in an assembly 8 to 10" wide.

Each section was jointed, and then run through the thickness planer so that each section was of equal thickness, then the sections were glued together. Four of the five sections made up the 3" thick part of the bench. The fifth section (of four boards) was the front part of the bench which houses the doghole strip, and was four inches thick.

I drilled the hole for the shoulder vice threaded rod though each section of the benchtop before gluing the sections together.

Below is a picture of two courses of the benchtop after glue up:



Two courses glued up and waiting

Following is a picture of the entire 3" thick section of the bench being glued up. Note that I had trimmed the ends of the sections to be approximately square before the glue up. It's at this point that you realize how heavy this bench will be.



3" thick part of benchtop being glued up

Three of the four 4" tall boards which form the front part of the bench were glued up, but the fourth board was left loose until the dogholes had been machined.

6 Machining the Dogholes and Planing Stop

Forming the dogholes was one of the more enjoyable jobs on this bench even though I typically don't like using routers.

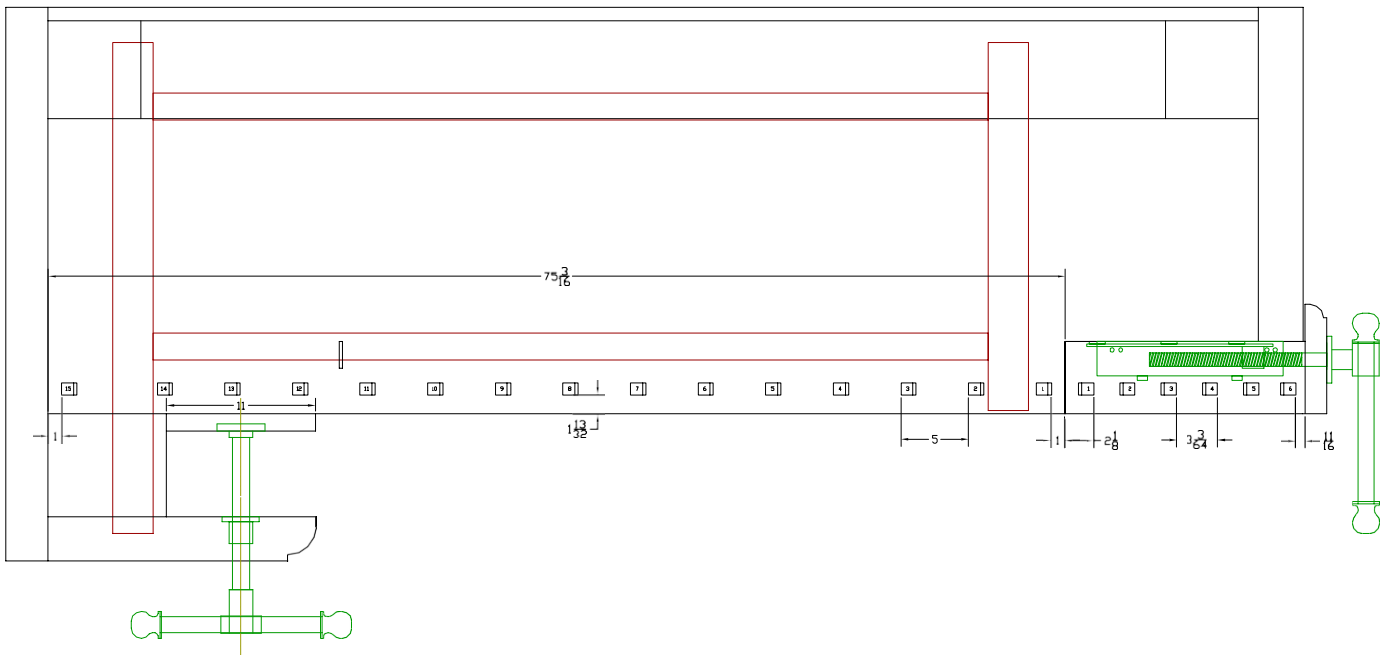
I used the benchdogs as guides for building a router template. The dogholes are installed at 88 degrees to the benchtop. I won't remind you to angle the dogholes in the correct direction – the reference books and magazines do a good enough job of that!

The dogholes were carefully spaced with a number of criteria in mind:

1. A doghole should not be located over one of the bases to avoid interference.
2. The first doghole should be located close to the tail vice face (I used a 1" gap between the tail vice face and the first doghole). Locating the first doghole close to the tail vice face allows short pieces (as short as 2") to be held in the tail vice.

3. Spacing of the remaining dogholes should be fairly close together. I aimed for a 4" spacing, but ended up with a 5" spacing to meet all of these criteria.
4. Dogholes, except for the last one, should be equally spaced for pleasing visual appearance. My doghole spacing was different on the bench body than it was on the tail vice (3 3/4" spacing)
5. Dogholes in the tail vice should not interfere with installation of the metal tail vice hardware. The tail vice is screwed into the doghole strip, so I located the dogholes so that there was no interference with these screws.
6. Frank Klausz locates the last doghole directly up against the end cap. I didn't like that, so I offset my last doghole about 1" from the end cap. I don't know which way is better or if it matters at all.

Below is a sketch of the top showing the benchtop, the bases, and the doghole spacing.



Benchtop showing doghole spacing (bench base is shown in red below the benchtop)

I used a 1/2" straight bit in my router to cut the dogholes. A guide bushing ran along the inside of the router template. The template was clamped onto the doghole strip.

The top of the template was 1/4" hardboard. Two pine guides (jointed 2x4s) were screwed to the underside of the template, sandwiching the doghole strip between them.



Benchdog and benchdog router template – top view



Benchdog template clamped in place – underside view showing one of the 2x4 guides



Routing benchdog holes



Benchdog in hole

Once all of the dogholes are cut, the last benchtop strip can be glued onto the doghole strip, covering up the dogholes. Note that I selected the nicest looking board to be the front of my bench:



View of dogholes before cover strip glued on

Finally, the doghole strip can be glued to the rest of the benchtop and filler strips can be added to the underside of the bench. Don't forget to drill the hole for the shoulder vice threaded rod, and to cut the slot for the planing stop before gluing the doghole strip onto the rest of the bench. It is also much easier to square up the tail vice end of the doghole strip now before it is glued to the rest of the bench.

Following is a picture of the planing stop. Like the dogholes, the planing stop was installed at an 88 degree angle to the benchtop. I wasn't sure I wanted this feature and at first I had trouble figuring out what this thing was when reading through the various books. However, I find it is very useful and I highly recommend installing this feature on your bench. I cut the slot on my table saw using the mitre gauge set at a 2° angle. It's a bit hairy manoeuvring a piece of wood this large on a standard sized table especially when a screw up might wreck a lot of hard work.



Planing stop



Benchtop before doghole strip glued in place (view from rear of bench) – doghole strip is 4” thick, remainder of benchtop is 3” thick.



Doghole strip glue to main body of bench place. Filler strips under the 3" thick section of the bench are in place. Hole for shoulder vice threaded rod is visible at back of benchtop.

7 Finishing off the Top – Filler Strip

The filler strips under the bench rest on the top of the bases. To accommodate expansion and contraction of the benchtop, only the front of the filler strip is firmly screwed to the benchtop. The back end of the filler strip is loosely screwed in place with room for expansion. A 1" diameter hole is drilled through the filler strip, and a matching hole is drilled in the base to accommodate a bullet dowel which connects the benchtop to the bases.



View of underside filler strip



Underside of bench showing filler strip and bullet dowel

At this point, you now have a working bench. I took the time to roughly flatten the bench so that things were close to flat and the bench could be used to dimension stock. At this point I also squared off the ends of the bench by clamping a straight edge across the benchtop and trimmed the ends of the bench with a router and a 3" long ½" diameter router bit, followed by fine tuning with a handplane.

8 Attaching the End Caps

Prior to attaching the end caps, I squared off the ends of the bench by clamping a straight edge across the table and running a router with a straight bit along the straight edge. I touched up the ends using a hand plane to get perfectly square and perpendicular ends. Precision now pays off later.

I had rough dimensioned the end cap stock to 3 1/4" wide by 4" tall at the same time as I built the bases. The pieces warped a bit during storage, so my end caps came in slightly under 3 1/4" wide once everything was straightened out. After the end caps were dimensioned, I cut slots into both the end caps and the ends of the bench to accommodate plywood splines. I used ~5/8" Baltic birch plywood as the spline material.

I cut the slots using a router with an edge guide. I always referenced the edge guide off the top surfaces of the bench and the end caps so that things aligned perfectly. The slots were cut in the centre of the 3" section of the bench.



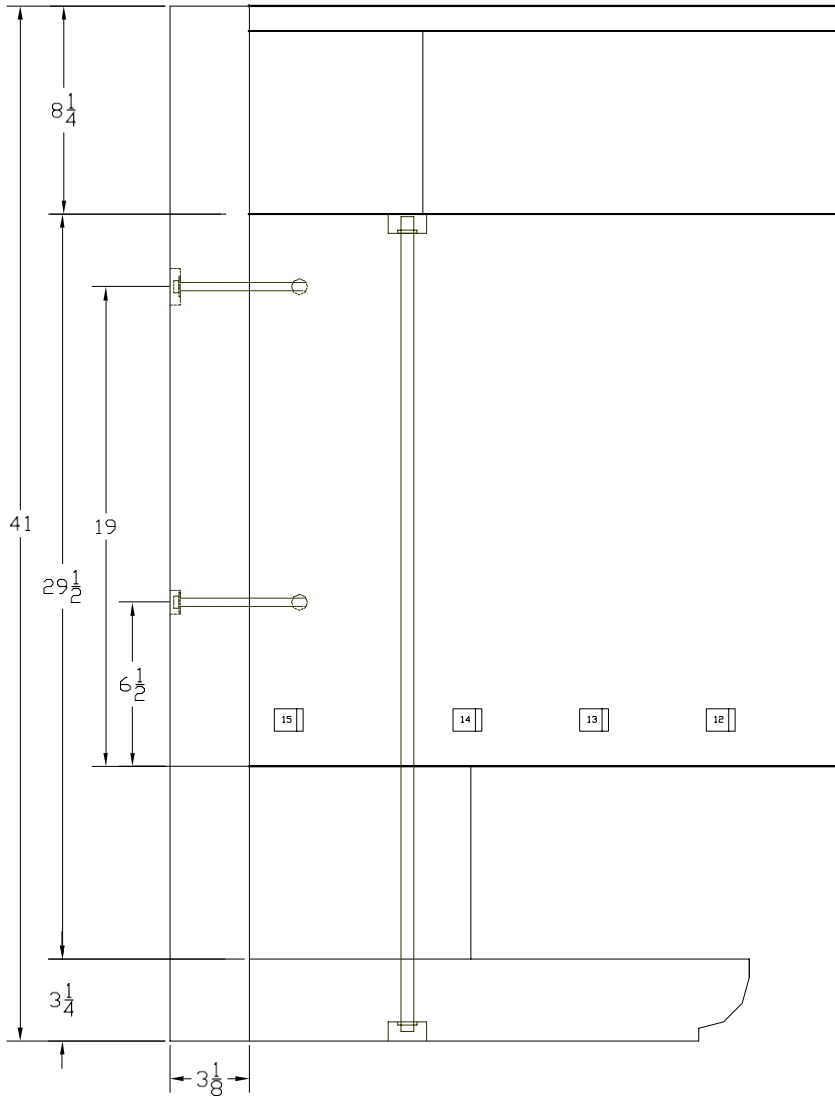
Spline groove formed in bench end

The end caps are held in place by gluing the front 4 6" of the splines (allowing the benchtop to expand/contract to the rear of the bench). There is also a fixed bolt near the front of the end cap and a bolt in a slotted hole near the rear of the end cap.

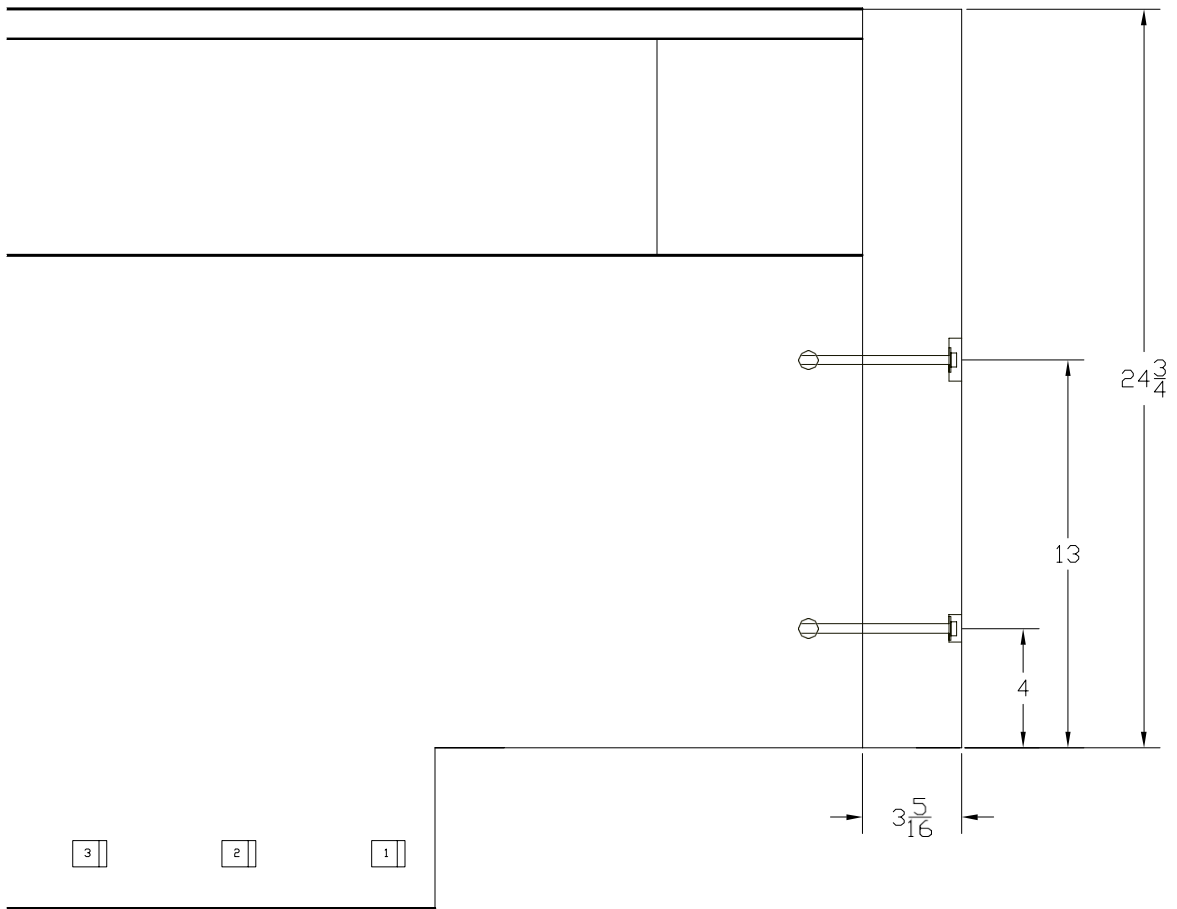
I actually cut the slots very slightly undersize and then used a hand plane to take shavings off the plywood splines until the splines were a tight fit into the slots. You don't want any play in the splines or else your end caps can move up and down.

I found that my first set of splines, which pressed into the grooves easily with hand pressure, allowed too much slop in the end cap attachment.

I made a second set of splines that I had to tap lightly into the grooves with a mallet, and these were much more acceptable. Don't make them too tight, however, or else when you apply glue to the splines and the splines swell a bit, you won't be able to get the splines into the grooves. A shaving or two makes all the difference between too loose and too tight.



Shoulder vice end end cap dimensions (end cap is $3\frac{1}{8}$ " wide by 4" tall)



Tail vice end end cap dimensions (end cap is $3\frac{5}{16}$ " wide by 4" tall)



End caps in place. Benchtop is getting very heavy. I had to turn the benchtop 180°. With only one person, it was a difficult task.



Shoulder vice end end cap showing bed bolt locations.

Note: Do not glue the end caps in place until the shoulder vice and tool tray back board have been completed.

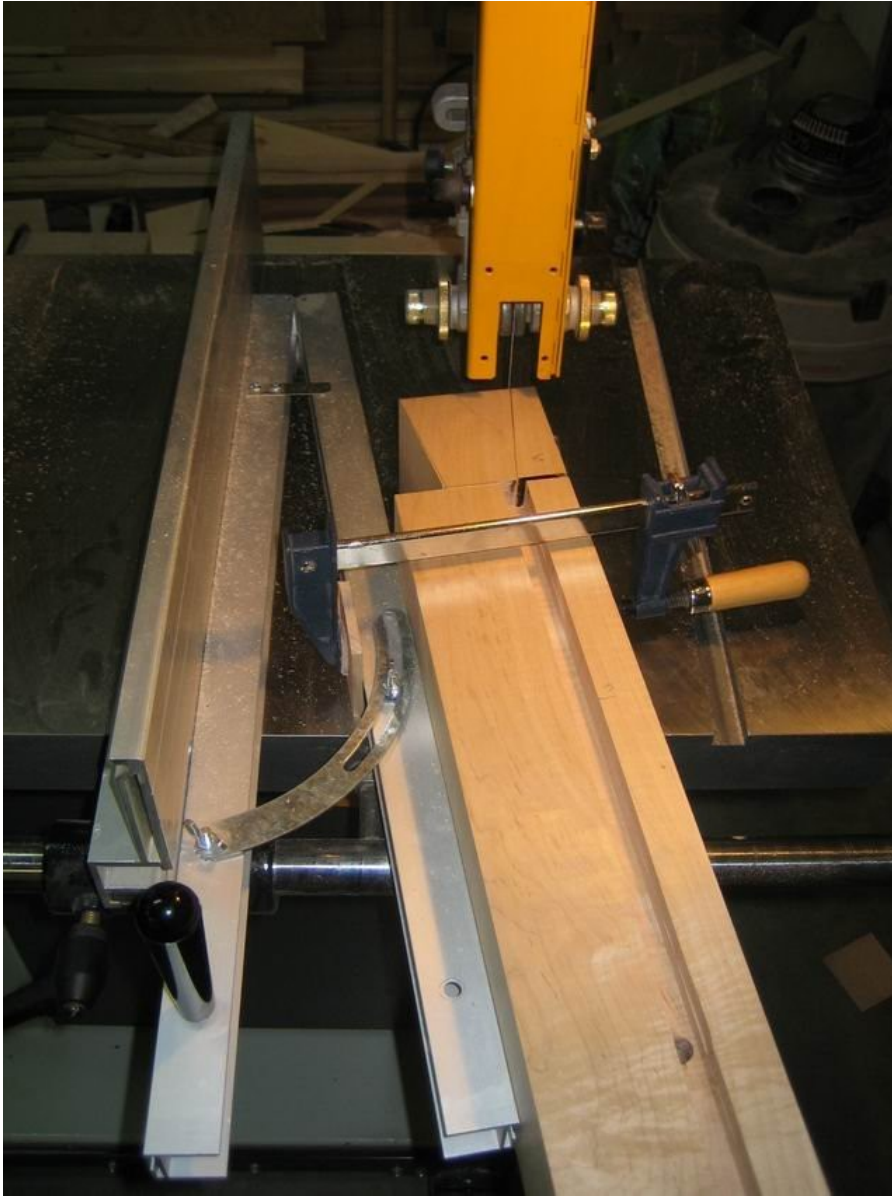
9 Assembling the Shoulder Vice

Now that the end caps were in place, it was time to assemble the shoulder vice. This was where the fun really began and I felt that I was doing some fine woodworking instead of heavy timber framing.

The shoulder vice uses a single large dovetail to connect the vice arm to the end cap. I laid out this dovetail with 5/8" thick half pins at the top and bottom of the joint. For hardwood I would normally use a 1:7 ratio for the dovetail, but I found that on the large joints such as are used on this workbench, a lower angle looked better. In the end I just eyeballed the angle and used a proportion that was visually pleasing.

I made the shoulder cuts first on the tablesaw, and then cut the dovetail on the bandsaw.

This is a large piece of wood and I felt it was too large for me to do a good job with a handsaw. I used a taper jig to ensure that the dovetail sides were nice and straight



Cutting the shoulder vice dovetail

Once the tail was cut, I transferred the tail onto the pin board. Because of the size of the pieces this isn't as easy as dovetailing a delicate drawer together. Since I had gone to great lengths to ensure that the end of my bench was nice and square, I ended up clamping the pieces to my bench at 90 degrees to each other, and transferring the markings. This worked pretty well. One shoulder was off a bit, but that was due to my over exuberance with a chisel and laziness not fixing it.



Transferring dovetail markings onto pin board

I also cut the pins using the bandsaw. This was a bit trickier than cutting the tails because I had to exactly match the angle of the pin board to match the angle of the tails. To cut this angle, I bevelled a board to match the dovetail angle. I used two sided tape to stick the pin board onto the bevelled board. Note that the resulting cut in the following picture was exactly vertical. The pin board ran along the bandsaw fence. This set up worked well and even though it was a bit finicky to get right, the whole process of cutting the pin probably took less than an hour.



Cutting the shoulder vice pin board on the bandsaw using an angled guide. Inside cuts were practice cuts. Outside cuts were cut very close to the line on bandsaw, then were cleaned up with a #60 1/2 rabbet plane.



Assembled shoulder vice dovetail before glue up

After finishing the joinery on the dovetail, I completed the shoulder vice by drilling the hole for the shoulder vice threaded rod, profiling the end of the shoulder vice arm, making the spacer block, and installing the shoulder vice hardware.



Exploded view of the shoulder vice

glued the spline between the end cap and the spacer block, but only glued the first four to six inches of the cross grain splines nearest to the end cap.



Underside of shoulder vice showing vice jaw and arm riding under the spacer block. Spacer block is allowed to expand/contract to the right side of the picture. Splines on left side of spacer block are glued.



Side view of shoulder vice showing arm riding on top of base

Note: Do not glue up the shoulder vice assembly until you have cut the joinery for the tool tray backboard into the end caps.

10 Assembling the Tail Vice

The tail vice was the most daunting part of this project for me. I used the small welded tail vice hardware available from Lie Nielsen. For some bizarre reason, tail vice suppliers think there is no need to include any instructions with their equipment. I realize each installation might be slightly different, but to not provide any installation guidance is questionable to me.

When Lie Nielsen started carrying a line of bench hardware, I decided to use that hardware instead of the Atlas version. The welded assembly is, I believe, easier to build than the Atlas version because there is no core to build.

The sliding tension adjustments on the LN version are very nice. The LN hardware was machined as a completed assembly square and true. The mounting tabs visible on the front and rear of the assembly have been machine ground parallel, the slots for the mounting plate have little slop in them, and the square thread screw is well machined.

Following are some pictures of the Atlas tail vice hardware and the Lie Nielsen tail vice hardware. I didn't take any pictures of the Atlas hardware or the LN hardware before installing it, so I "borrowed" pictures from their respective web sites:



Atlas tail vice hardware (picture from Atlas Machinery



Small welded tail vice hardware – view from front (picture from LN website



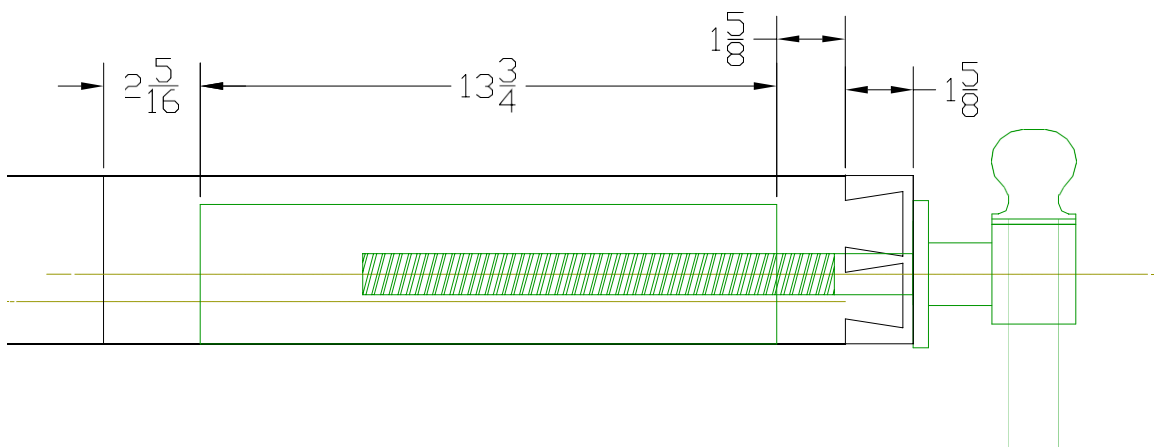
Small welded tail vice hardware view from backside (note I modified one of the bolts to be shorter than the other bolt). Handle end of the vice is to the right and upper side of vice is in foreground of picture.

The LN tail vice hardware came with two bolts, each consisting of a 10 mm diameter bolt with a cap screw tapped into one end of the bolt. These bolts were well machined and fancy looking, but there was no indication as to what purpose they had. A little hint might have helped here!

The tail vice assembly is actually pretty simple, but it took me a long time to understand how the whole shebang works and should go together.

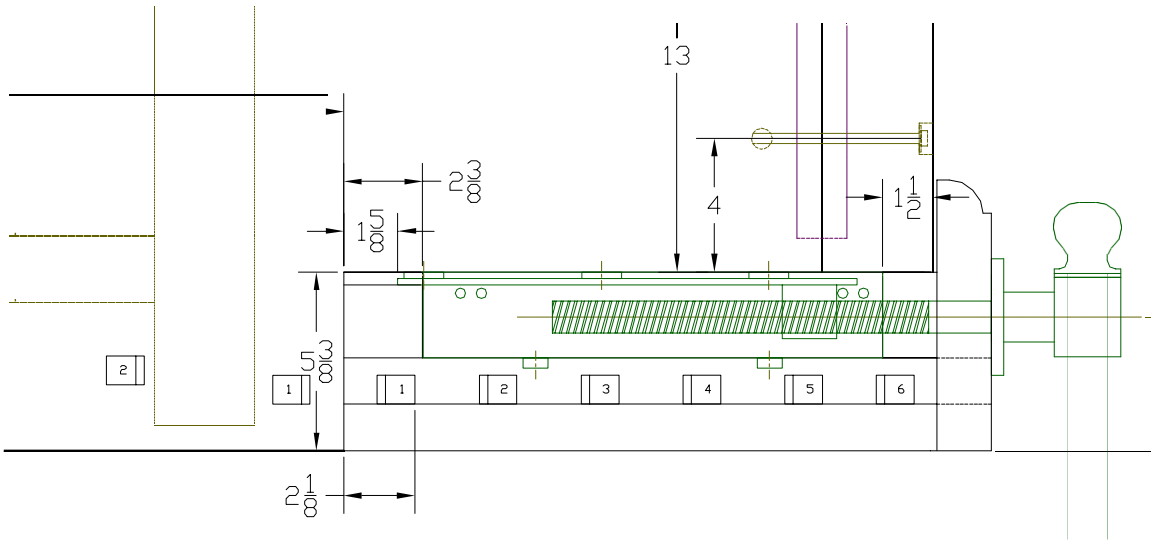
I took the time to make dimensioned drawings of the whole assembly. Note that some of these dimensions are very exact to fit the particular installation on my bench.

Below is a front view of the vice.

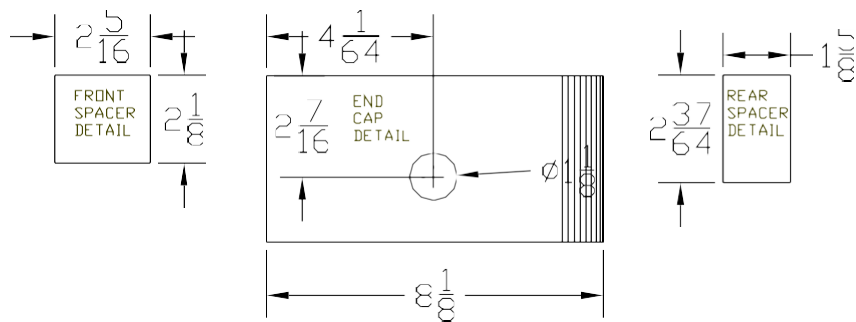
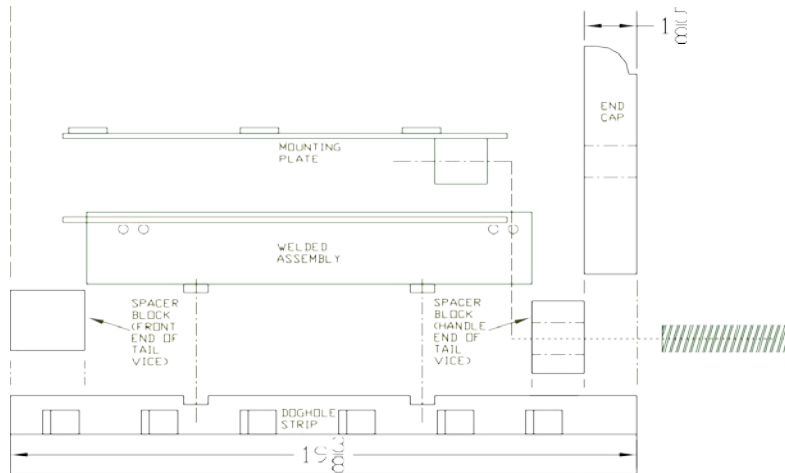
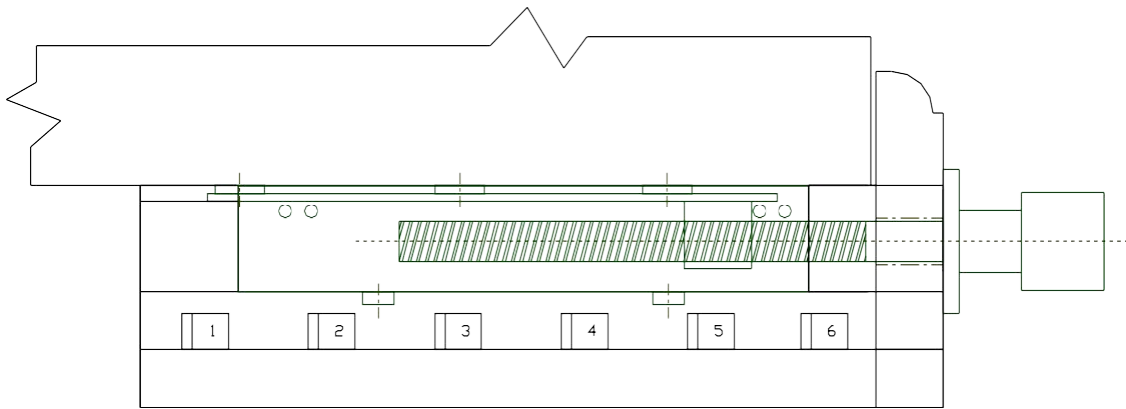


Tail vice front view (note handle sticking up above benchtop). Tail vice hardware was installed flush with the bottom of the bench.

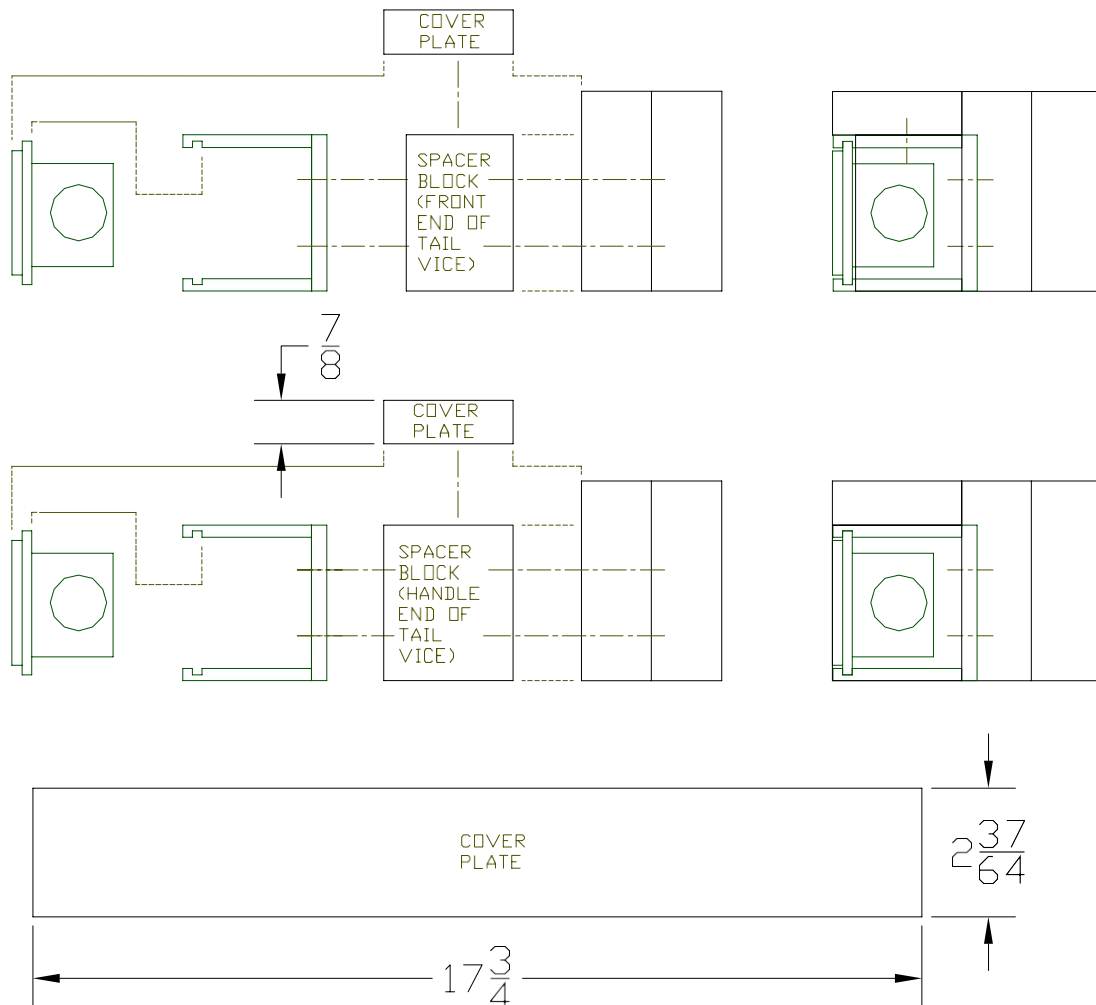
One thing I would do different if I was to build this bench again would be to make the doghole strip section of the bench 5" tall instead of 4" tall. This would have given me more flexibility in the vertical location of the tail vice. One thing I don't like about the arrangement below is that, in certain positions, the tail vice handle sticks up above the plane of the benchtop. Particularly when using a jointing plane, the handle sometimes interferes with my planing.



Top view of tail vice – note 1/8" gap between end of bench and inside of tail vice end cap



Exploded top view of tail vice and details of spacer blocks and tail vice end cap.



Exploded end views of tail vice

The tail vice assembly is made up of eight pieces:

1. Tail vice mounting plate (the stationary part of the tail vice hardware that is screwed and bolted onto the bench)
2. Tail vice welded assembly (the parts of the tail vice that slide back and forth along the mounting plate)
3. Tail vice screw and handle
4. Doghole strip (the front two boards which extend the length of the tail vice and house the dogholes)
5. Spacer block at front end of tail vice
6. Spacer block at rear end of tail vice
7. Cover plate (covers the front spacer block, the rear spacer block, and the tail vice welded assembly)
8. End cap (end cap is dovetailed to the doghole strip).

The first step in assembling the tail vice is to mount the stationary mounting plate onto the bench. On my bench I mounted the end of the plate 1 5/8" from the vice opening. Ensure that the plate is mounted perfectly parallel to the top of the bench. Drill pilot holes for the four screws (I used #14, 2 1/2" long stainless Robertson screws) at the left side and middle of the plate. Drill holes for the mounting bolts at the right end of the plate. Note that my mounting plate was slightly bowed when taken out of the welded assembly. This had the effect of slightly shifting the hole locations. When the mounting plate was housed within the milled slots of the welded assembly it was forced to straighten out. I thought it was best to lay out the pilot hole locations with the mounting plate trapped within the welded assembly.

Below is a picture of the vice location after the pilot holes had been drilled:



Screw and bolt holes note the dirty marks on the wood are because I screwed the plate into the wrong location the first time and had to plug the holes with dowels and drill new holes

Unfortunately I did not take a picture of the mounting plate bolted in place.

To make room for the mounting bolt nuts, I had to route a recess into the bottom of the bench. I used an edge guide on the router and a 3" long 1/2" straight bit. To make it easier to get a wrench in there, I shortened the lower bolt and used a stepped hole:



Underside view of mounting bolts (mounting plate visible at bottom of picture). The brass nut visible at the top is one of the bed bolts holding the end cap in place.

Once the mounting plate is in place, I measured the exact spacer block sizes required. Two pictures of the spacer blocks, doghole strip, mounting plate, and welded assembly are shown below. Note that the welded tabs on the front of the welded assembly were recessed into the doghole strip.

The long grain of the spacer blocks was aligned with the long grain of the doghole strip so a nice strong glue joint was achieved when gluing these together.



Tail vice assembly. Spacer blocks are glued to doghole strip. Then cover plate is glued on top of spacer blocks and is screwed to the welded assembly

Before gluing the spacer blocks onto the tail vice assembly, I filed the ends of the welded assembly exactly square and perpendicular to the doghole strip and spacer blocks. This allowed me to butt the spacer blocks right up to the metal parts so that forces could be transmitted through the block into the metal assembly. At this time I also drilled the hole for the bench screw through the handle end spacer block before gluing it in place.



Spacer blocks in place – March 05, 2006

Finally, I glued the cover plate to the top of the spacer blocks and to the doghole strip, and screwed the welded assembly to the cover plate and doghole strip using #14 stainless screws.

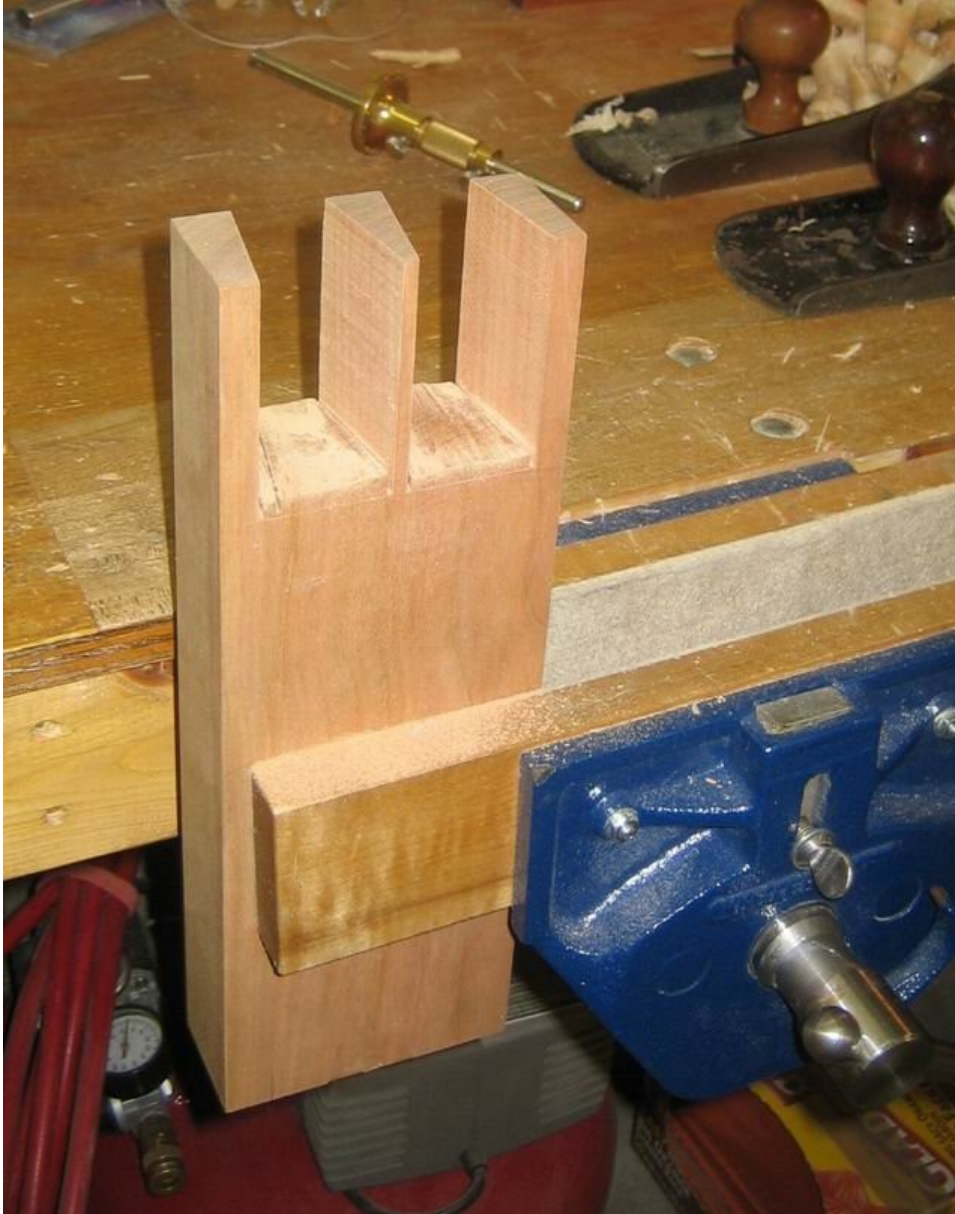
To attach the tail vice end cap, I first trimmed the handle end of the tail vice assembly to the desired length, ensuring that the end was perfectly square. I left a 1/8" gap between

the inside of the end cap and the end of the bench. I cut the dovetails on the tail vice end cap using the same method as was used for the shoulder vice. The finished tails are shown below.



Dovetails cut for the tail vice assembly end cap

Next I transferred the tails onto the pin board and cut out the pins:



Tail vice end cap pins roughed out

Once the dovetail joint was complete, I profiled the end of the end cap, drilled the hole for the tail vice screw, and glued the dovetail joint together. I mounted the tail vice, screwed the handle flange onto the end cap, and adjusted the tail vice tension screws for nice smooth operation.

As a final step, the handle supplied with the tail vice was undersized compared to the hole through the casting.

There was $7/32$ " of clearance (almost $1/4$ ") between the handle and the casting which made the handle very sloppy. The original handle was a 12" long length of 1" diameter maple dowel. I replaced my handle with a $1\ 1/8$ " diameter hardwood dowel which made the handle operation much nicer. A slightly larger diameter handle would have been slightly better, but $1\ 1/4$ " was too large to fit into the casting.

Here are some pictures of the assembled tail vice:



Finished tail vice (note undersized diameter handle) – March 13, 2006



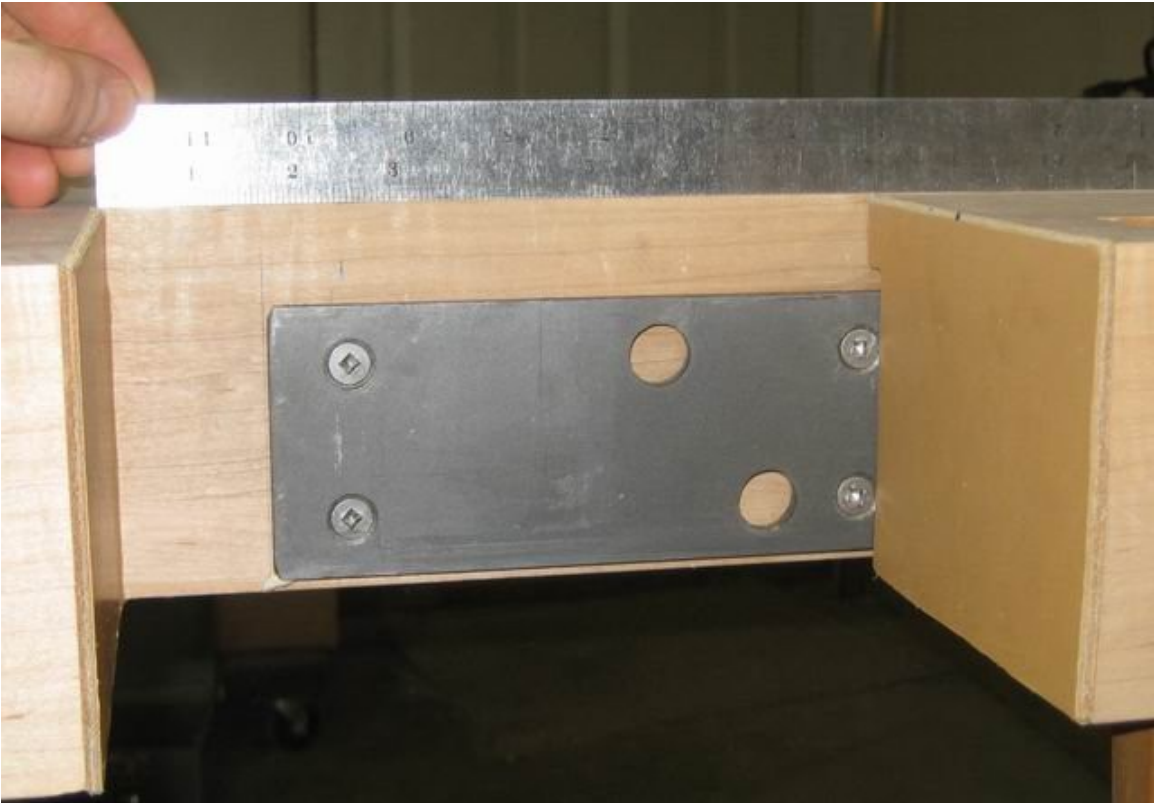
Underside of tail vice partially open position



Underside of tail vice closed position. Note that the jaws close very tightly to each other. By ensuring that the ends of the tail vice and the dog hole strip were perfectly square before glue up and assembly of the vice the jaws fit perfectly and I did not have to make any corrections.



Backside view of tail vice assembly at maximum opening



Tail vice at maximum opening 8" available between jaws. Both sets of mounting screws are accessible from the front and the two bolts are accessible from the underside of the bench



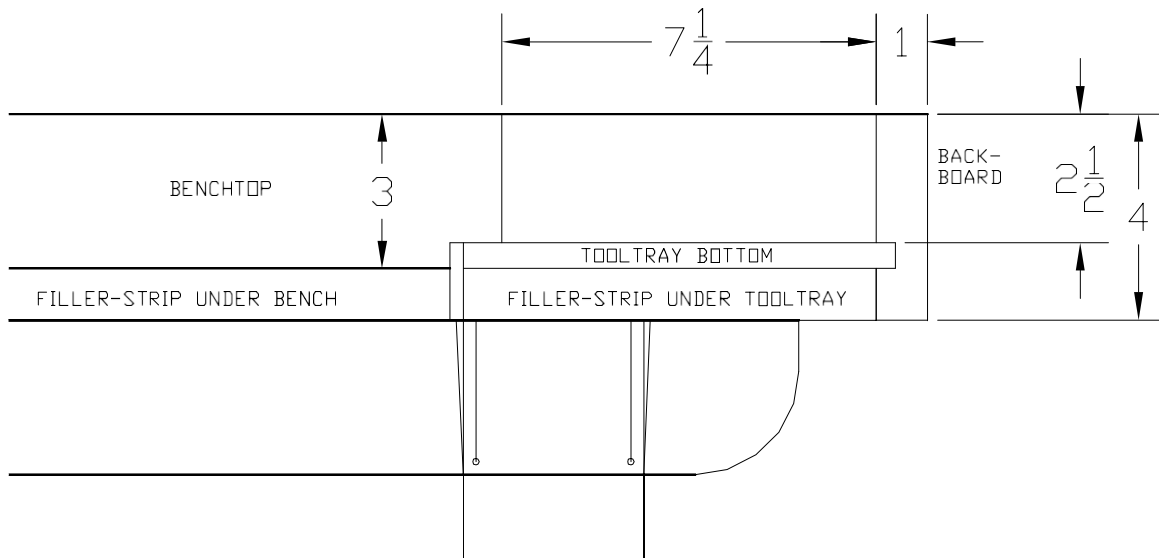
Tail vice jaw lined with leather glued in place with 180 gram strength hide glue.

The never ending project was getting closer to completion! There was still a surprising amount of work left to do.

11 The Tool Tray

The tool tray was the second to last thing to finish, next to finishing. I like having a tool tray, but admit there are times when it fills with shavings and generally becomes a mess. I played with a number of ideas such as removable lids, flip stops to prevent shavings from getting into the tool tray, and a bunch of other crazy notions, then decided to just get on with it and build the darn thing.

After obsessing over every little detail, I decided not to glue my tool tray into the backboard. Instead I attached glue blocks onto the underside of my tray, which were then screwed into the backboard.



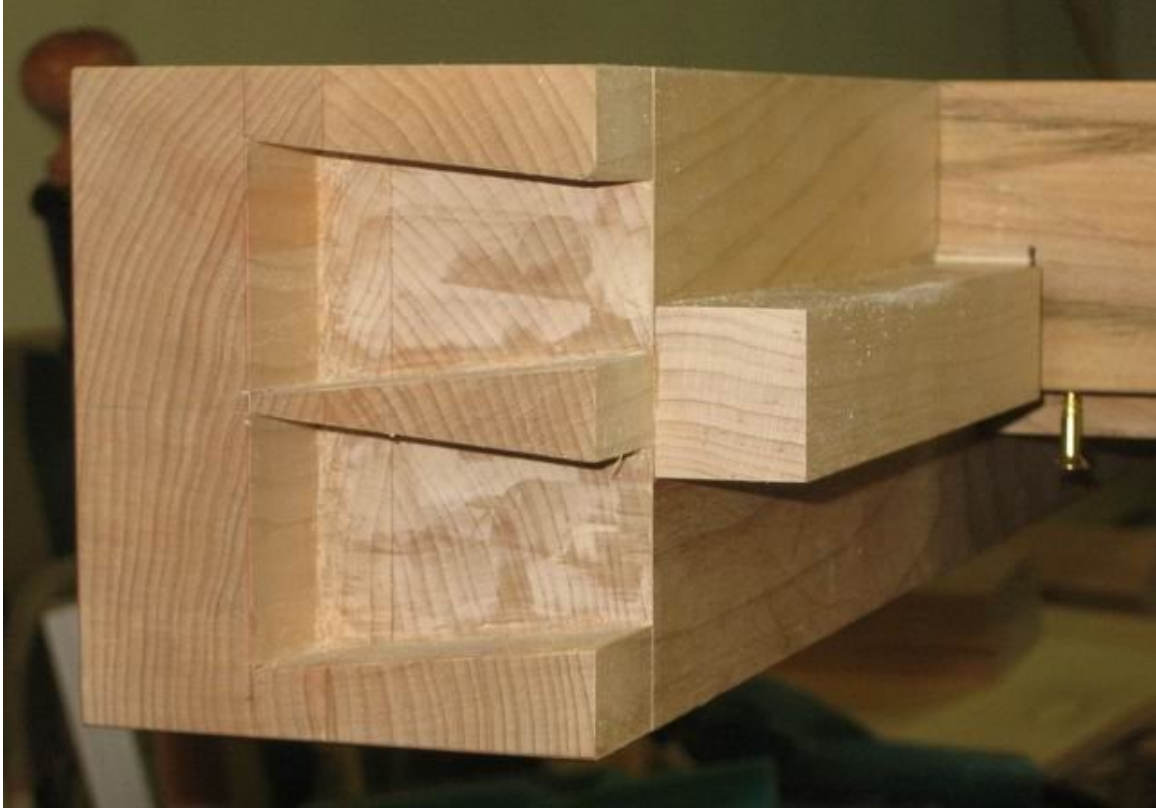
Tool tray end view dimensions

The first step was to dimension the backboard and cut the dovetail joinery. The critical dimension for the backboard was the EXACT distance between the end caps. This set the distance between the dovetail baselines.

On my bench, I set my baselines a couple thousandths of an inch more than the distance between the end caps. When fitting the dovetails I used a skewed rabbet plane to take a few shavings off the inside of the end cap pins until the end cap baseline distance exactly matched the distance between the end caps.



Backboard tails



End cap pins (glue block is to support the tool tray ramp). Note the slight shavings taken off the inside face of the pins. This was done to get an exact fit between the back board dovetail baseline distance and the exact distance between the two end caps. Don't break off a corner of a pin when taking the shavings off (like I did).



Completed joint before glue up

Once the joinery was completed, I cut a ½” dado in the backboard to house the plywood bottom. The dado passed through the lower tail on the back board.

I glued five glue blocks to the underside of the tray, and screwed those blocks to the backboard. This kept the tool tray bottom fixed to the back board. I could have glued the tray into the back board dado, but I wanted to keep the option of removing the tool tray in the future. The tray turned out to be more trouble to remove than I thought it would be, so if I were to build the bench again, I would go ahead and glue the tray bottom to the back board.

On the other edge of the tool tray bottom, I cut ten slots for #8 screws, and loosely screwed the tool tray bottom into the underside of the benchtop. The slotted holes should allow the benchtop to expand and contract. I left ½” of room for the bench to expand. A picture of the arrangement is below:

Finally, I installed some spacer blocks under the tool tray, aligned with the support bases.



Underside of bench showing tool tray bottom, glue blocks, slotted screw holes, and spacer blocks

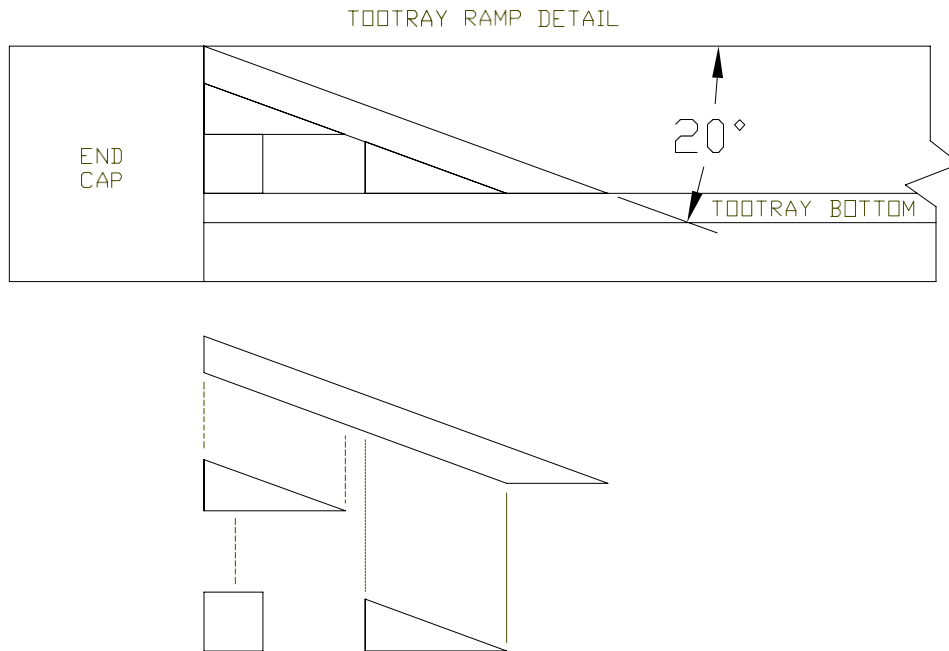
The tool tray ramps were the final challenge on this bench. All of the bench building write ups I've seen simply say something like "the tool tray ramps were glued in place". No explanation of how to handle the expansion/contraction issues is given.

If the tool tray ramp is cut to exactly the width of the space between the benchtop and the backboard then, when the bench expands, the tool tray ramp will be pushed backwards putting pressure on the backboard. It seemed clear to me that some allowance for expansion/contraction had to be made. But every bench I had a chance to look at did not make any allowance here. It didn't make sense.

I decided that my tool tray ramps would be removable so that I could adjust their width in the future if there was a need. I also played with the idea of allowing one ramp to flip upwards, with a cut out in the tool tray bottom under the ramp, so that garbage could swept through the hole. In the end I didn't cut the hole, but this would be easy enough to add in the future.

I attached my tool tray ramps using two rare earth magnets. I eyeballed the ramp angle, and decided that 20 degrees was about correct. The angle on the upper end of the ramp was cut on the table saw with the blade at 20 degrees. The lower end of the ramp (with

the acute angle) was cut with the ramp held vertically in a tenon jig with the same table saw angle setting.



Tool tray ramp arrangement

The ramp was made of 5/8" plywood. The two angled pieces under the ramp were glued to the plywood. The approximately 1" square piece was glued to the end caps and had two 1/4" magnets embedded into it. The square piece was cut 6 3/4" long, and was glued tight up against the back board – this gave the workbench top 1/2" of room to expand if required. The magnets hold the ramp quite securely and I am happy with the installation.

The only weakness is that the leading edge of the ramp is quite delicate and I am sure this edge will get beat up by tools being placed into the ramp. A glued down ramp would not suffer from this weakness as much.



Tool tray ramp supports



Tool tray ramp magnets (square block is glued to end cap)

Just for fun I veneered the top of the tool tray ramp with cherry crotch veneer and the underside of the ramp with plain sawn cherry veneer. This was the first time I attempted hammer veneering with hide glue and I was very impressed with the process and the results.



Finished tool tray ramp with cherry crotch veneer (approximately 1/8" gap allowed between plywood part of the tool tray ramp and the workbench to allow for expansion/contraction)

12 Final Glue up and Finishing

Up to this point the end caps had not been glued to the benchtop, the joinery for the shoulder vice had not been glued, and the backboard had not been glued to the end caps.

I now glued everything up, flattened the bench, and applied many coats of Lee Valley's polymerized Tung oil as a finish. I have to admit that I spent more than a minute or two admiring the bench while the finish was drying. It really looked good.

I had a bit of tearout on two of the more difficult boards that made up part of the benchtop laminate. I left this tearout because to remove it, while maintaining benchtop flatness, I would have had to remove another 0.5 mm of thickness from the entire benchtop. At the end of the day, it's just a workbench... but a darn good looking one.

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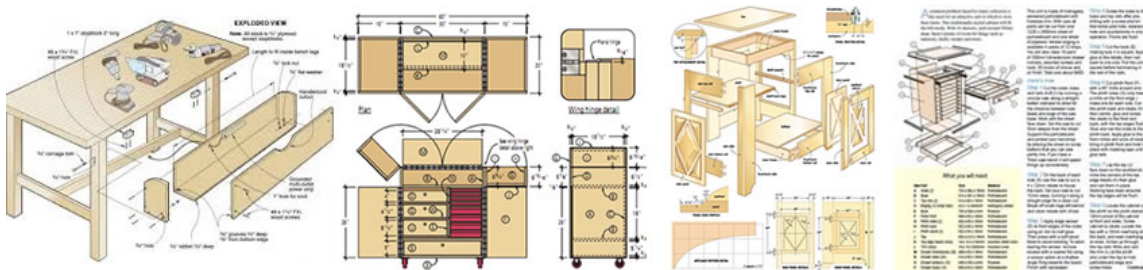
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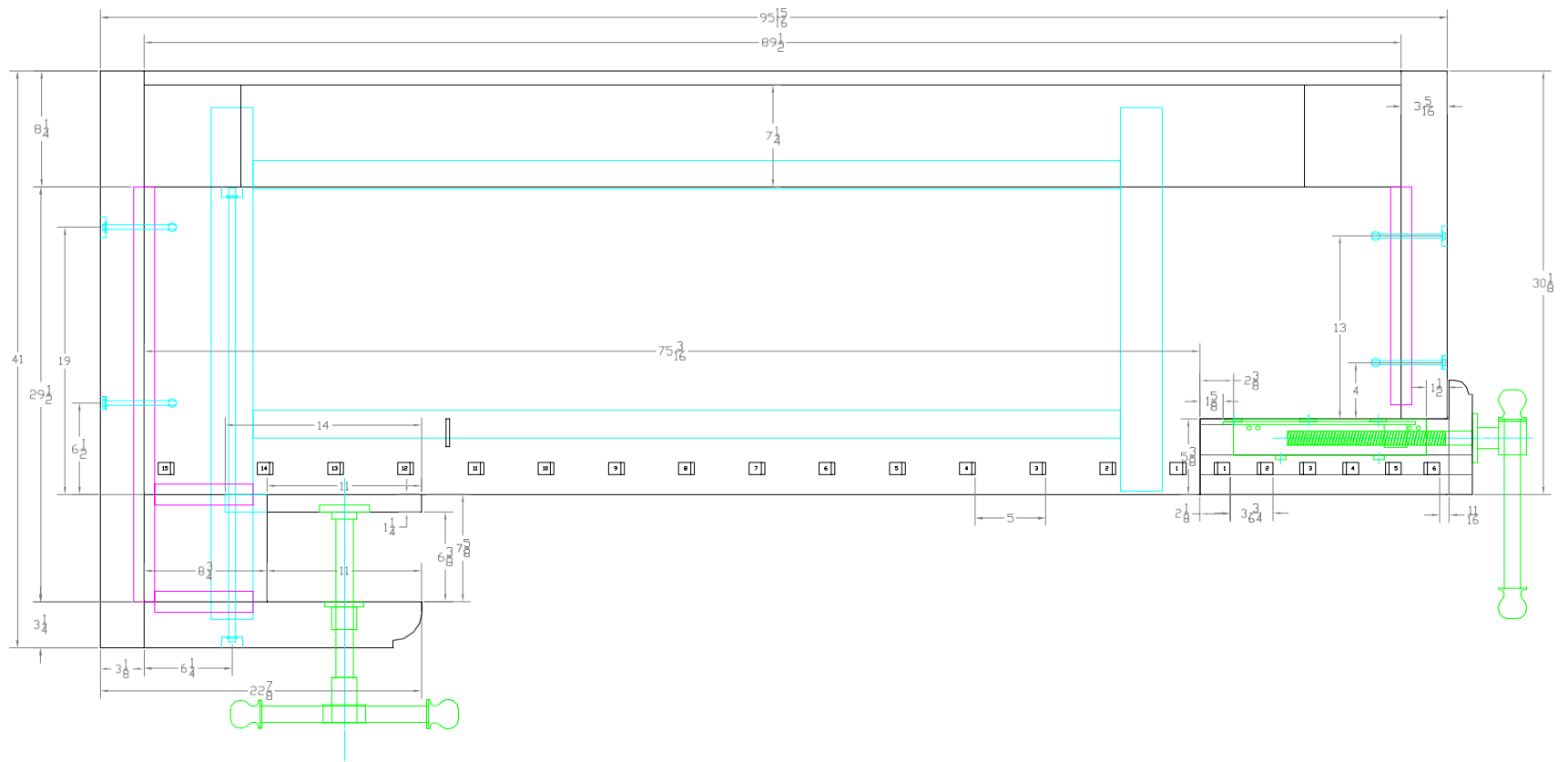
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13 Appendix A: Drawings

Notes on drawing conventions

Black lines = major equipment
Cyan lines = hidden or centre lines
Green lines = tail vice hardware
Grey lines = dimensions
Purple lines = splines

Certain details, such as showing that tenon shoulders exist on the legs, are sometimes omitted. Some critical dimensions depend on the particular installation and should be modified by the user to match their installation.



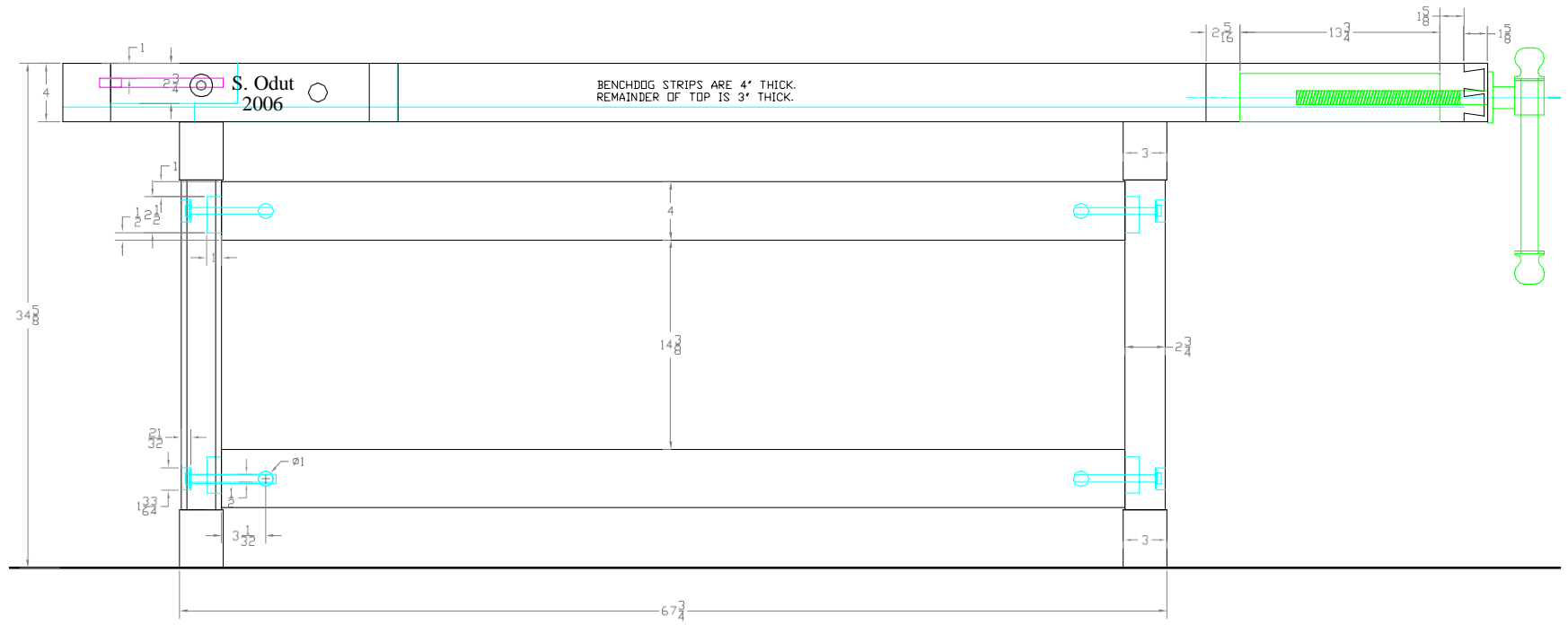
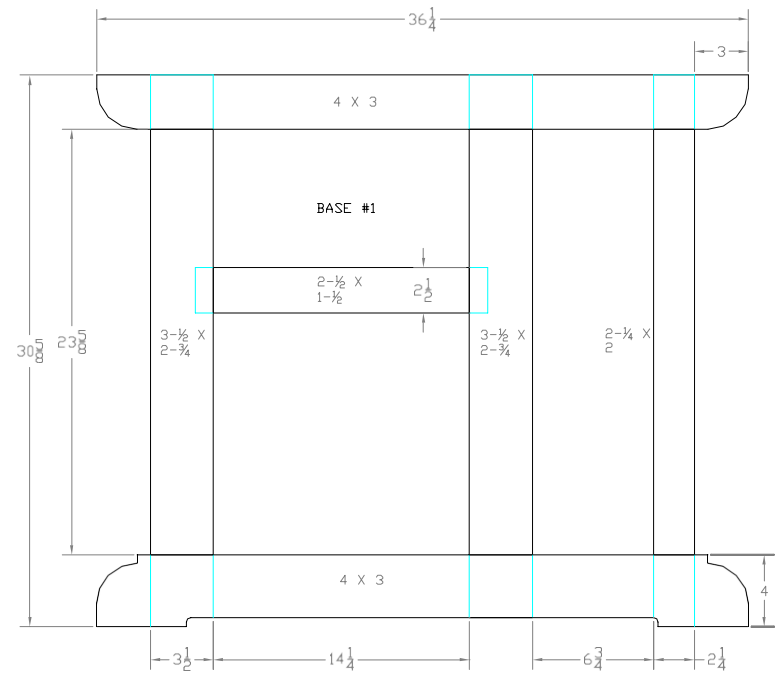
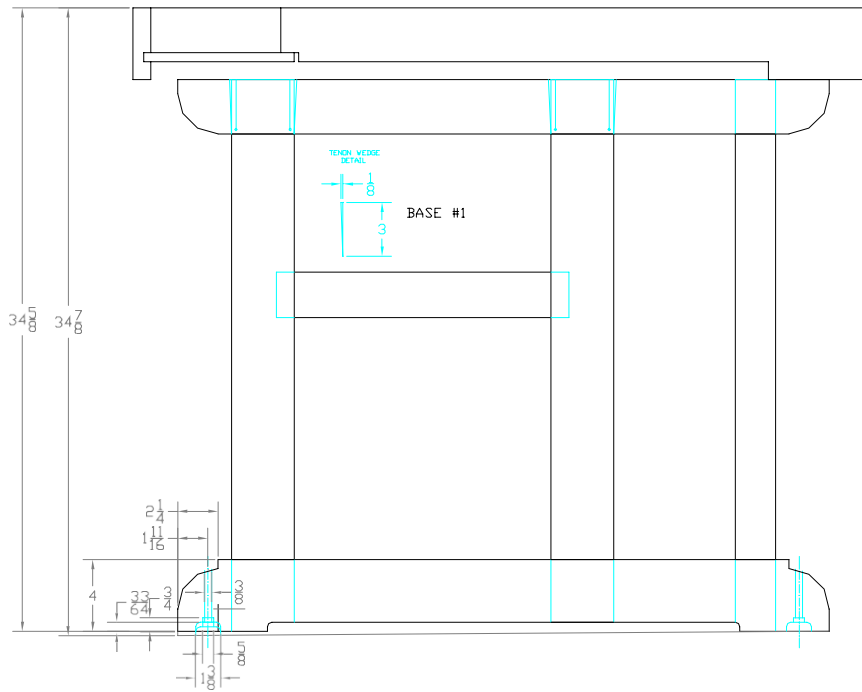


Figure 102: Front view



NOTE: DETAIL SHOWING SLIPPING FLUID IN GARAGE AND LEVELLER FOOT FOOT DIMENSIONS ARE EXACT - DRILL OVERSIZE HOLES!

Figure 103: Shoulder vice end base drawings

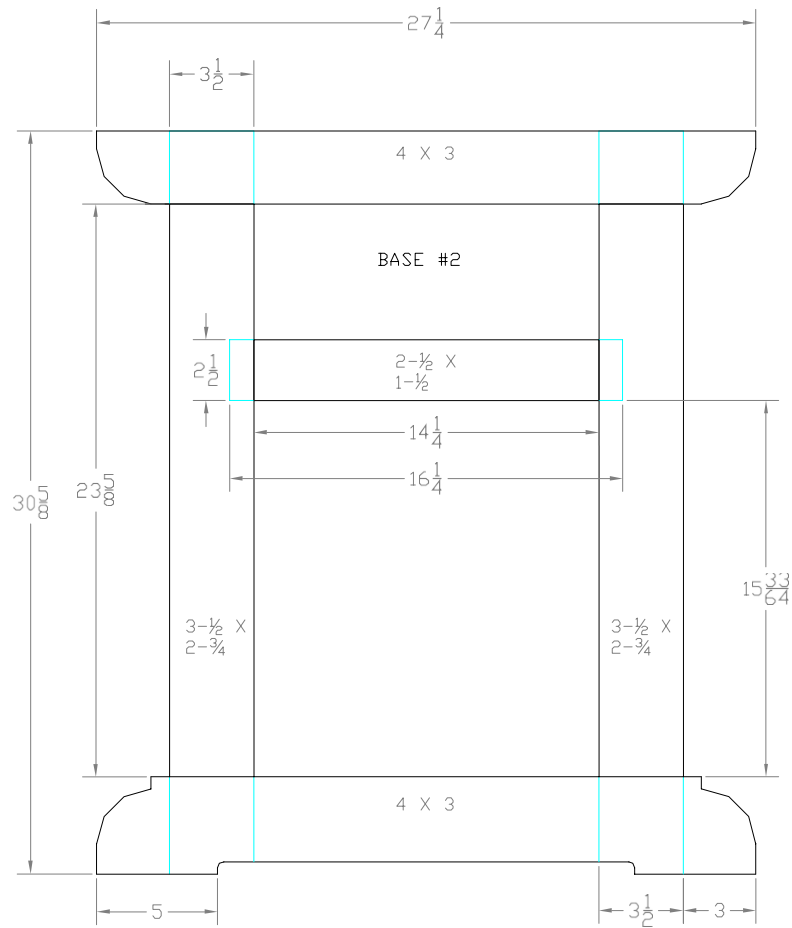
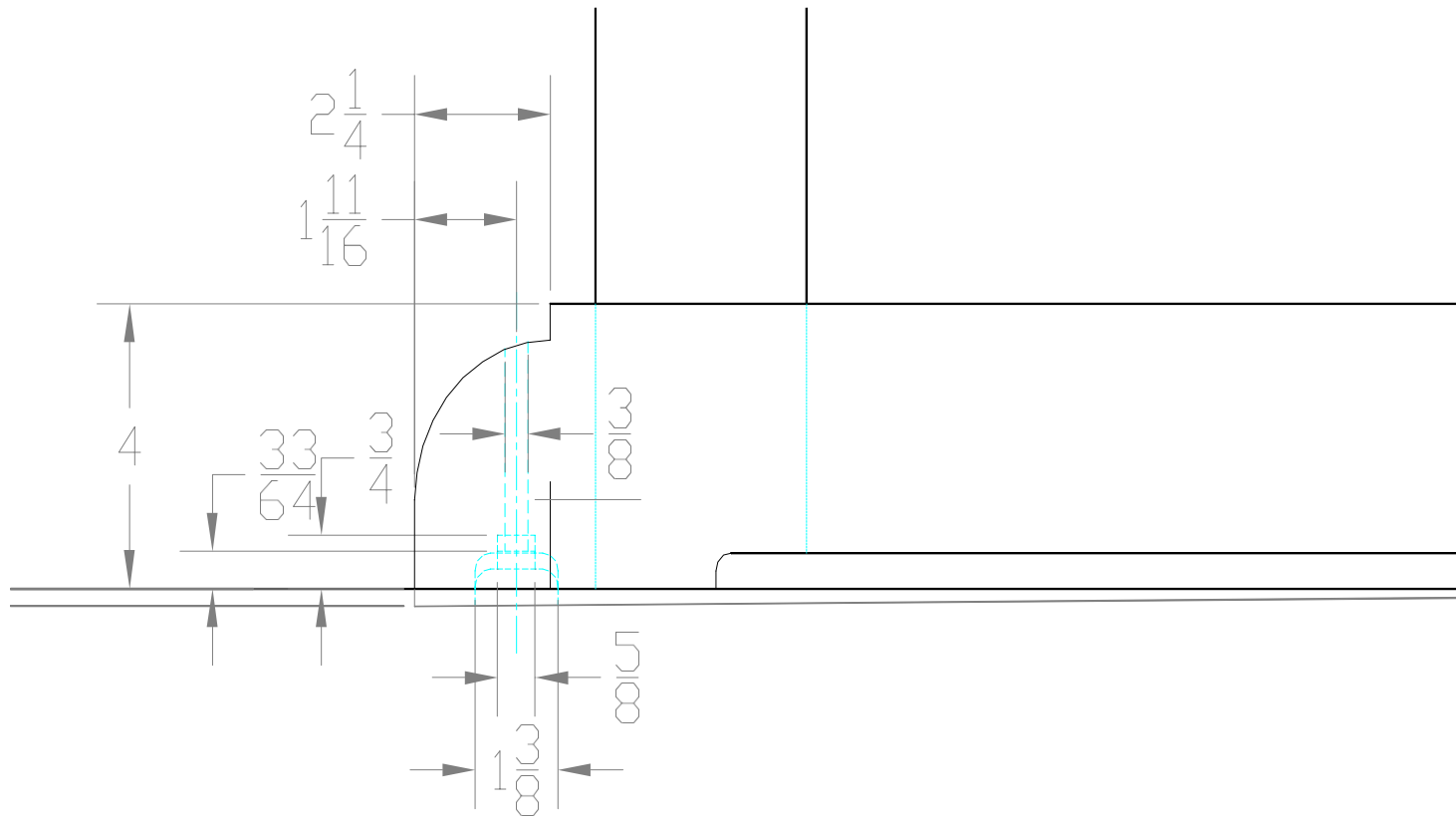


Figure 104: Tail vice end base

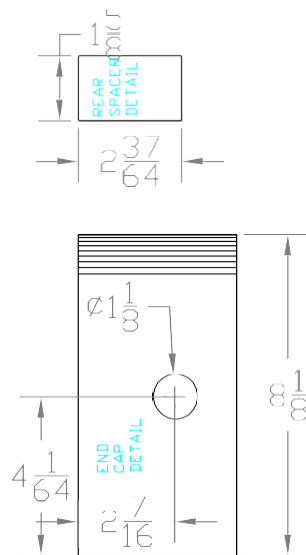


NOTE: DETAIL SHOWING SLOPING FLOOR IN GARAGE
AND LEVELLER FOOT (FOOT DIMENSIONS ARE EXACT - DRILL OVERSIZE HOLES)

Figure 105: Leveller detail



Figure 106: Stretchers



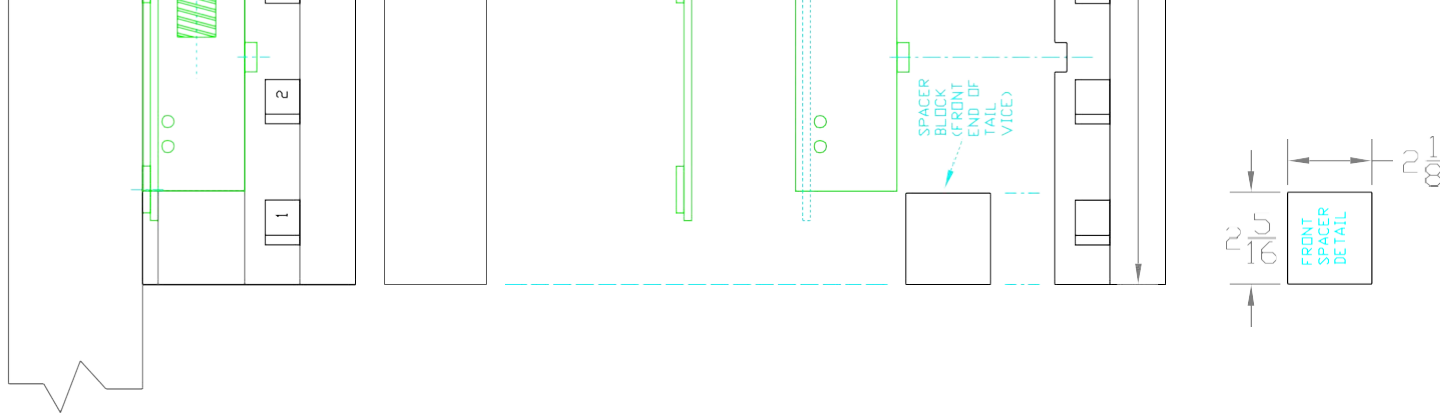


Figure 107: Tail vice assembly drawing

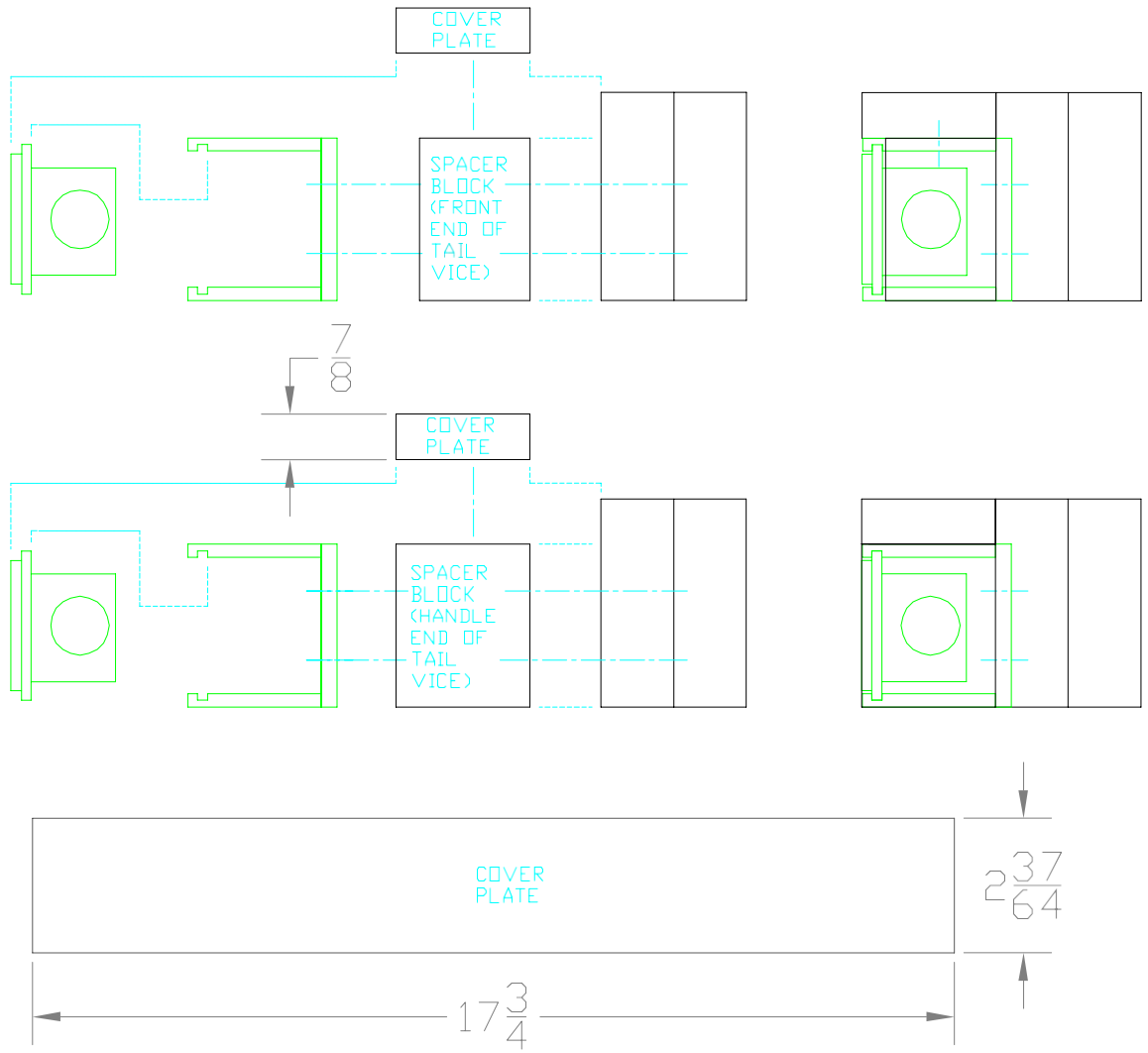


Figure 108: Tail vice end views exploded diagram

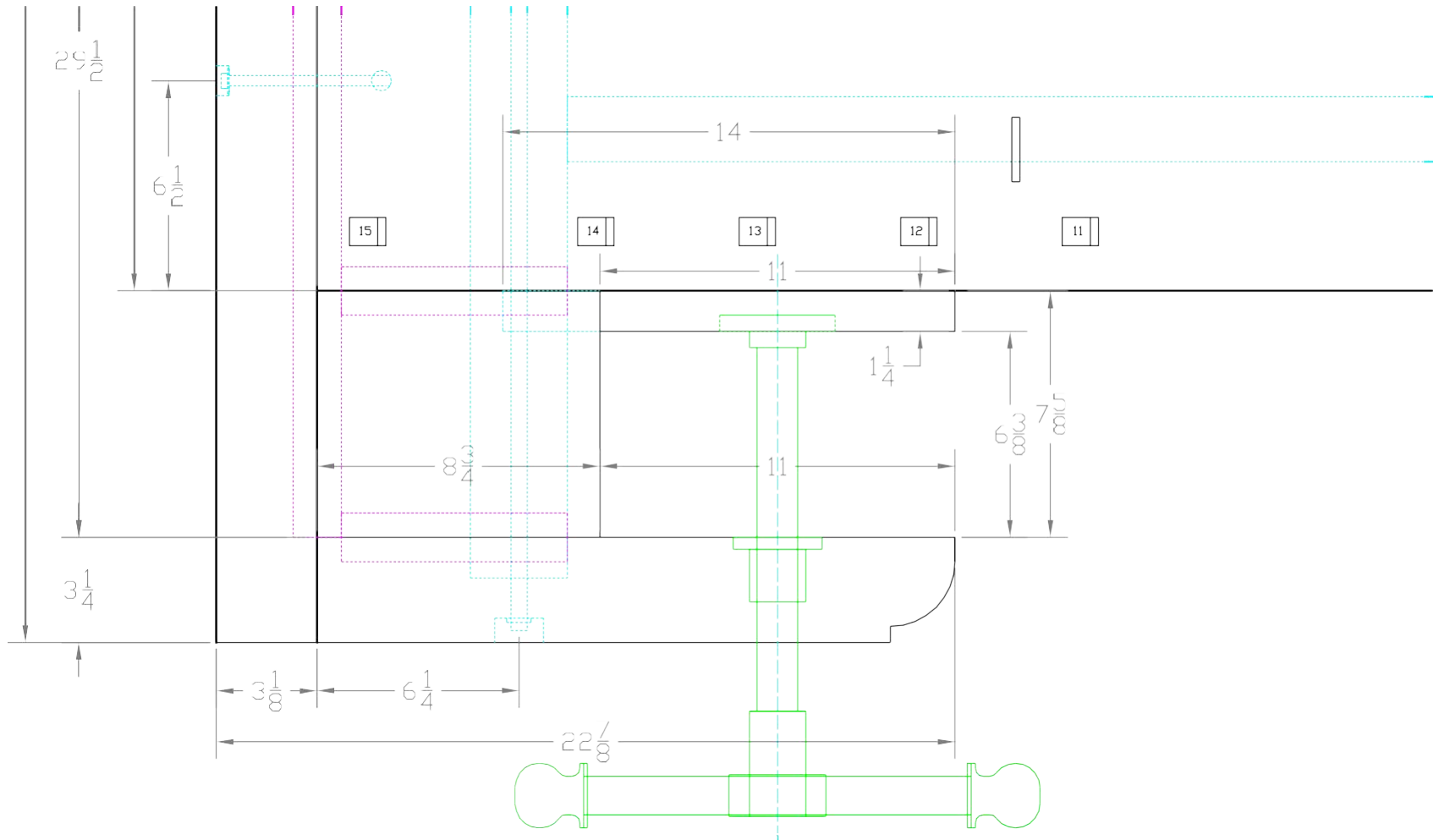


Figure 110: Shoulder vice detail top view

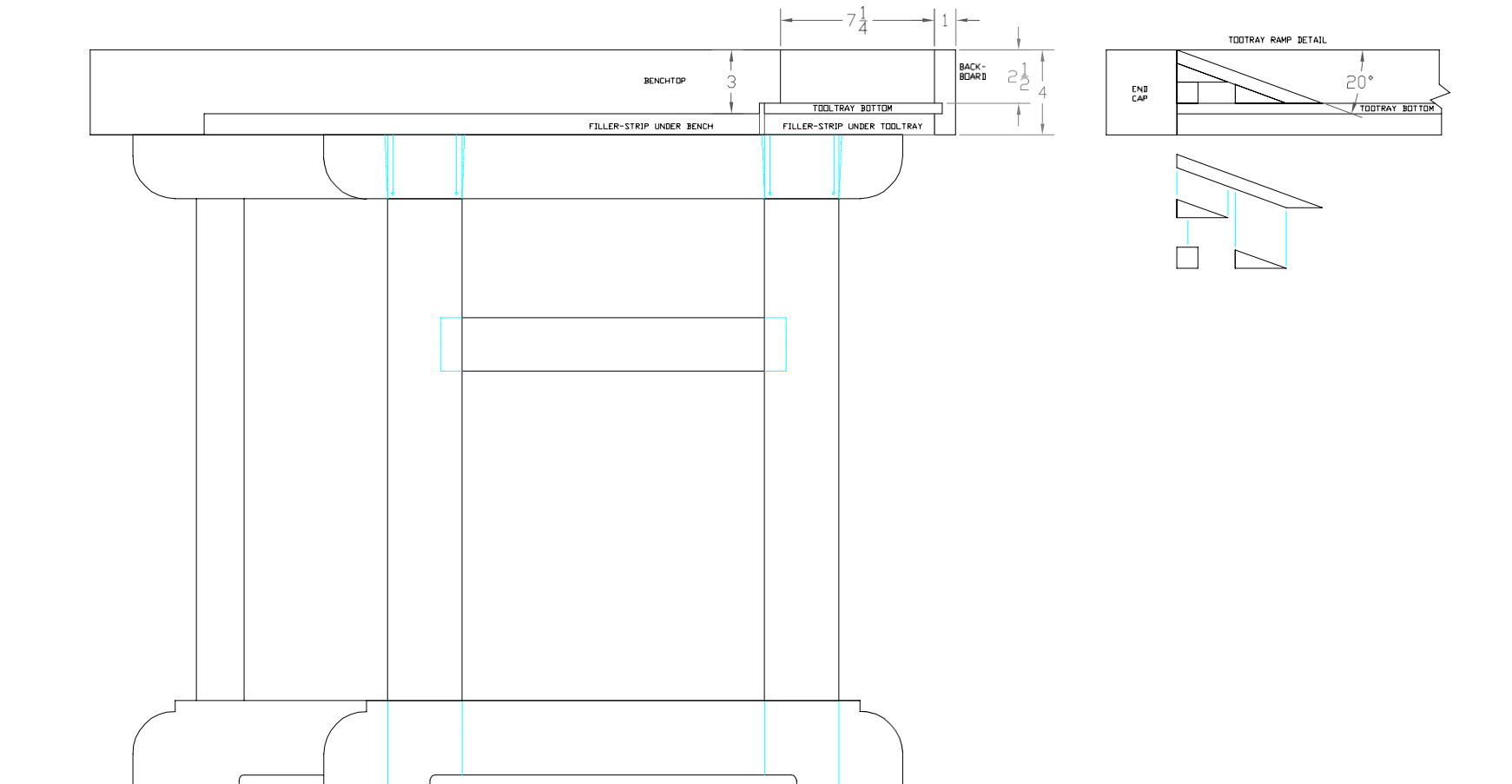


Figure 111: Tool tray