A Quick-Change Gearbox For The 7x Minilathe

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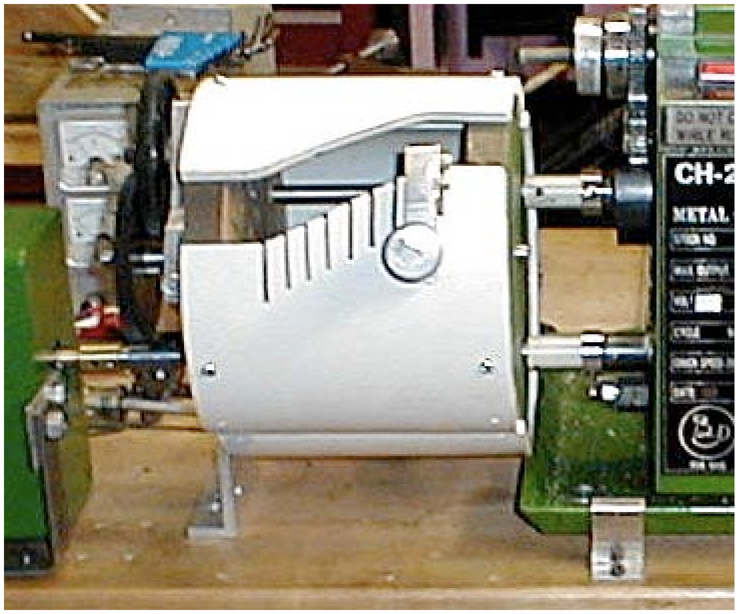
10 August 2002



This article describes how to a build a quick-change gearbox for your 7X minilathe. I'll describe one that I built as a prototype for testing and show you how you can build your own. The gearbox requires no change to the 7X lathe, and it presents the lathe stud gear and screw gear shafts on its left end for convenience. This allows you to continue using any accessories that attach to the left end of the lathe. For example, I'm able to continue using my motor-driven fine feed gadget for a mirror finish by simply attaching it to the outboard end of the gearbox.

The gearbox will cut from 6 to 416 tpi in six 8-step ranges. The 8 steps are available via the gearbox selector handle. Range change consists of an easy change of one or two gears on the outboard end of the box. The higher ranges provide fine feeds down to 0.0024 inches per spindle revolution. Diagram 1 shows the whole gearbox schematically. (Diagrams, tables and figures appear at the end of the article.) Tables 1 and 2 show the available threads per inch (also some feed rates). Some metric capability is shown in Table 2. These Tables will be useful as set up guides when using the QCGB.

The gearbox requires only the gears that came with the original package. As you'll see, however, I bought a few extras to make the gearbox more convenient to use, and I made some unusual size gears to support the metric capability.

All in all, I'm very pleased with this project. Although I built it as a prototype, it works so well that I will probably keep right on using it as is!

The following sections describe the construction of the quick-change gearbox. I built mine using mostly parts from the scrap box, and I encourage you to adapt the project to match what you have available. I hope you have as much fun building your gearbox as I did developing this prototype.

Making The End Frames

The gear-change assembly is housed in three segments of 6-inch diameter schedule 40 PVC pipe. Start by making 2 identical end frames. For trial purposes I used MDF plywood and will probably keep mine that way, as it is rugged enough for my use. You may choose metal or plastic for yours. Figure 1 shows the hole layout. The only critical dimensions are the stud to screw shaft locations. Mine are as shown. Please check the measurements on your lathe. After marking the hole locations, rough cut two 6+ inch discs and mount them together on a faceplate. Then turn their diameters to exactly fit the PVC bore. Before you remove the discs from the faceplate, cut a section of the PVC pipe about 2 inches long, slip it on the discs and face one end of the PVC. This piece can be used later to hold the discs in line while drilling the bearing holes. All told, you will need about 16 inches of the PVC pipe.

Bushings

I bought six 3/8-inch ID x 1/2-inch OD oilite flanged bushings 1 inch long for the bearings. Cut them down to 3/8 of an inch before installing, and save the cut off pieces for use in making the couplers to be described later. Install the bushings in the holes drilled in your end frames with the flanges on the inside. I found the bushings at ACE hardware.

Shaft Assemblies

Next we need to make the internal parts: shafts for the "D" and "B-C" gear groups and one for the stud shaft extension. These parts are shown in Figures 2 thru 6. Figure 2 just shows the scheme for the gear stacking arrangement with spaces for fillers or spacers to suit the materials you have on hand. The other figures are mainly lathe jobs. If you use 1/2 inch diameter 12L14 shafting for the two shafts in Figure 3 it will be a snap. I suggest that you do these shafts between centers. A good feature of the 12L14 is that the lead makes the metal slippery and makes sliding the shifting lever smoother.

I cut the keyways using a 1/16-inch wide slitting saw and two parallel passes down the center of the shafts as needed. Measure your gear slots before choosing a keyway width. Be aware that some of those molded gears have draft in the key slots-they taper a bit for easy removal from the molds. As a result, some filing of the slots and the keys may be needed.

The stud shaft extension is a length of 3/8-inch drill rod with some flats milled on its ends as per Figure 4.

Housing And Shaft Couplers

Saw off a 6 inch long piece of the 6-inch diameter PVC pipe and true the ends. Now the eight "D" gears along with spacers and end fillers can be stacked on it's respective shaft and that assembly and the other two shafts can be installed between the end frames and tested for fit while inside their temporary housing.

This is a good time to make the couplers shown in Figure 7. I used 1/2-inch PVC water pipe (Genova). Remember the pieces of oilite we cut off the bushings? True up the ends of two pieces and press one into one end of each of the coupler PVC pipes. Drill and tap through each pipe and bearing assembly for a setscrew. Then, using two pieces of 3/4-inch thick aluminum rod, drill and ream 5/8-inch holes through them. Press these sleeves on the other ends of the couplers and cross drill and tap for brass set screws. The setscrews will serve as driving "keys" by extending into the key slots on the lathe screw shaft and stud shaft. Using brass screws won't damage the keyways on the lathe shafts. Now you can drive your box with lathe power and observe it for trueness. You can make a temporary foot to anchor the outboard end of the box from aluminum angle. This will let you back off to take a good look!

Now back to work. We need to modify the housing. Tap the gear assembly out of the PVC pipe and stand the pipe on end on a flat surface. Draw a pencil mark up the outside of the PVC and square to its end. Measure 12 inches around the circumference and draw a second line. Now saw along each of the lines and separate the two sections. The large section can now be snapped over the end frames radially with a little push and will hold the assembly together without any fasteners! Save the smaller piece for later use.

Sliding Mechanism

We need to make the sliding mechanism and a few more collars to finish the inside stuff. The slide assembly is shown in Figure 8. Two 40-tooth gears (I bought 3 extras) were used for the drivers. They are shown in Diagram 1 as "C" and "K" gears and again in Figure 8. I added Figure 8A to clarify the drawings in Figure 8: it shows layouts of the main parts used in the sliding mechanism.

The sliding mechanism's frame should be assembled on a faceplate to hold the frame true for boring the hole for the slide shaft. You can use a 4-jaw chuck (or maybe a 3 jaw if it opens up enough) to hold the frame true for boring as well. I put a piece of paper (0.003 inches thick) between the 40-tooth gear's mesh when marking the location of the tapped hole for the shoulder bolt. This gives a suitable amount of clearance for these gears.

The handle extension as shown is too long and will have to be trimmed to fit your job. Holes will be needed to mount the handle. All that is best done when the gearbox is completed and assembled.

At this point, you need to install a 1/8-inch square key as long as the width of the 40-tooth gear in the gears keyway. Slip the slide shaft through the frame, spacer, and gear assembly making sure the key stays inside. Test and adjust for free sliding on the shaft. Adjustment usually amounts to some tedious polishing of the sliding surfaces.

You will need a bit of play inside the frame so as not to jam the gear. The width of the spacers and gear should match the width of the frame spacer shown in figure 8. I didn't show width dimensions for the spacers, as that will depend on the materials you use.

The other 40-tooth gear needs an oilite bearing (you have some pieces). The bearing must be fitted to the gear's 12mm bore and to the 3/8 inch O.D. of the shoulder bolt. Then you can mount the gear, bearing, and some spacers on the frame and test the whole slider.

Banjo And Journal

Now we can work on the parts needed outside the box. Start with the new Banjo as per Figure 9. I used a piece of 3/8-inch thick aluminum bar. Again the boring should be done with the unit mounted on a faceplate. Also shown in Figure 9 are measurements for a shaft fitting the "I" and "J" gear pairs to the banjo. It is similar to the one furnished with the lathe (part 60) but a little longer with the shaft diameter made to fit an oilite bearing.

Keep the 80/20-tooth compound gear and shaft that came with the lathe. They will eventually be mounted to the new banjo for the fine-feed function. (These parts are metric, so the gear bushings are not compatible with the parts you will be making later in this article.)

Next make a journal using aluminum rod or plate, as shown in Figure 9A. Mount it to the end frame concentric with the lever slide shaft. The journal will support the banjo and allow it to rotate in order to adjust the mesh of the "I" gear to the stud gear "A". (See Diagram 1.) You will also need some one inch long oilite bushings, 1/4 inch ID x 3/8 inch OD to serve as bearings for the "I"/ "J" gear pairs which you will make up.

Shift Handle

The shift handle assembly is shown in Figure 10. The handle is best made from a 1/2-inch thick aluminum bar about 2 1/2 inches square. Lay it out as shown and mount it in a 4-jaw chuck to turn the plunger extension on the handle. Drill and ream a 5/16 inch hole while the handle is mounted in the chuck, and tap it 3/8-24 about 3/8 inch deep. The curvature on the edge nearest the PVC box cover will be at a 3 1/4 inch radius. Cut out the shape using a saw or band saw, then file, sand etc., to make it look nice!

I found a center drill that measures 5/16 inch on the large diameter with a 1/8-inch drill point and this is perfect for drilling the shifter locking holes when we reach that step. The center drill body just fits the hole in the handle and will align the 1/8-inch hole to be drilled later in the PVC slotted cover. It stands to reason, then, that the plunger point diameter will depend on the size of your center drill!

I found the spring in my junk box. It measures 1 1/2 inches long, 7/32 ID, 9/32 OD and 0.020" wire diameter. The parts are fitted into the handle in the order shown in the Figure. The brass plug keeps the spring from escaping out the back end while the knob fixed to the plunger shaft via a setscrew won't allow the plunger to fly out the front.

Adaptors

You will need some adaptors to fit the 3/8-inch diameter ends of the shafts to the 12mm bores of the gears you got with your lathe. Figure 13 shows how I made them. They work really well. I used an aluminum shaft through the adaptor bores to hold the brass key in place while soldering it. I cleaned up the excess solder using a small end mill and the bores using a 3/8-diameter reamer.

Housing

We need to extend the area in the upper right quadrant of the gearbox housing (looking from the outboard end) to make room for the shift assembly. Figure 12 shows how I did it. I cut crescents from some MDF material, and fastened them to the end frames as shown in the figure. I fastened them using dowel pins and glue. Try to maintain a 3 5/16-inch radius on the outer arc of the crescent and a 3-inch radius on the inner arc. These dimensions are not too critical.

We will have to cut some pieces of the 6-inch diameter PVC pipe to make a top cover and a slotted cover for final assembly. Figure 14 shows what is needed in general.

Fit the PVC sections around this crescent with your shift lever in place. This way it will be easy to mark. You will find that the ID of the pipe closes up a little when it is split lengthwise and won't fit the circumference of the end discs exactly. I heated them with a hair dryer and pinched them in a vise to reform the pieces. They will retain the new radius, when they cool down.

The PVC piece containing the slots and locking holes must be marked on site. I cut the slots using a small band saw, but you may find another way that will make them look better. You will note that the slots do not line up with the threading gear centers because of the offset handle extension, so marking the slots on site is the easiest way to go.

Don't drill the locking holes [for the plunger in the handle assembly] until you are sure that everything lines up the way you want. The locking holes are not marked on my sketch of the slotted plate, but they will be needed in order to cut left handed stuff without the load pushing the selector gears out of mesh! Also without the locking holes the mesh of these gear teeth will tend to be pulled tighter when turning right-handed stuff, and this is not desirable. The locking holes support the slider in position when the plunger point falls into its respective hole.

A couple of sheet metal screws hold the covers in place. Place the top cover as the final operation so that you will be able to see into the box for purposes of lining things up.

Using The Quick Change Gearbox

To make things handy, I purchased 3 extra 40-tooth gears, 1 extra 30-tooth gear and 1 extra 80-tooth gear from LMS at a cost of about 25 dollars, which is about what I spent on this project. I used leftovers from the scrap box for most of the other materials. In order to cut metric threads, you'll need a 47-tooth and a 37-tooth gear. I made my own set since they are not listed in LMS.

If you study the drawing in Figure 11, you can see the arrangement of the "A", "I", "J", and "B" gears for all thread cutting functions.

The "I" and "J" gears are always in compound (keyed together) and always run mounted on the banjo's movable shaft. Because the 80/20-tooth gears furnished as a pair with the lathe are a pain to separate, they are dedicated as my fine feed gear pair. Figure 11 shows them in place. The Figure also shows the other two "I/J" gear pairs required for full operation of the gearbox.

The "A" and/or "B" single gear changes will allow the range changes as shown in the Tables 1 and 2.

You will probably want to operate the lathe at slow spindle speeds for threading. I run the spindle at 80 RPM, which is easily checked by slowly increasing the speed from low, (about 60 RPM with my controller) while strobing the 45-tooth gear on the left end of the lathe spindle under a fluorescent lamp. The first clear strobe 'stop' will most likely occur at 80 RPM (the gear will appear to have twice the number of teeth). The next 'stop' will display the correct number of gear teeth (full size) and will be160 RPM. Always a good test!

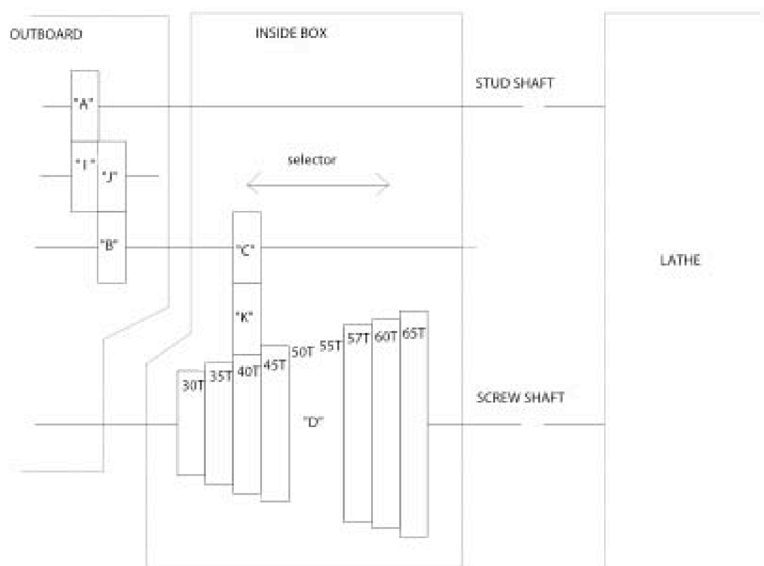
Notes On Loading

Whenever you add additional loading (like the quick-change gearbox) to a small machine, (like the 7X lathe), you need to be sure your motor/controller is up to the task. I measured an AC current of 1.5 amperes while driving the lathe carriage at the highest lead screw speed (6 tpi). Just driving the lead screw itself through the gearbox draws 0.6 amperes. I didn’t measure peak current—controllers using Mosfets may be sensitive to high peak currents. My controllers are SCRs, which work just fine.

On the subject of load, by far the best improvement I made to my lathe was to add a 2.5 times mechanical speed reduction using compounded pulleys. I installed the pulleys where the motor was mounted and moved the motor back just enough to make room. This allows me to run the 2.5 times faster for a given spindle speed and makes the whole system much more reliable. I made this change about two years ago and have been pleased with it.

Illustrations

The diagram, tables, and figures referenced in the text are collected below:



"A" is stud gear and can be changed
"I" and "J" are compounded idlers and can be changed
"B" and "C" are compounded, "B" can be changed
"K" is an idler and part of the lever with "C"
"D" is the lever selected change gear driving the screw shaft

Diagram 1: QCGB Schematic

OUTBOARD GEARS					tpi @ 'D' gear = x x teeth feed/rev @ 'D' gear = x x teeth							
A	I	J	B		30T	35T	40T	45T	50T	55T	60T	65T
80	80	40	20		6	7	8	9	10	11	12	13
80	80	40	40		12	14	16	18	20	22	24	26
40	80	40	40		24	28	32	36	40	44	48	52
20	80	40	40		48	56	64	72	80	88	96	104
20	80	20	40		96 0.010	112 0.009	128 0.008	144 .007	160 0.006	176	192 0.005	208
20	80	20	80		192 .0052	224 .0044	256 .0039	288 .0035	320 .0031	352 .0028	384 .0026	416 .0024

Table 1

A	I	J	B		mm@ D=							
					30	35	40	45	50	55	60	65
20	47	37	20				1.25		1.0			
20	47	37	40						0.5			
20	47	37	80						0.25			
40	47	37	20				2.5		2.0			
40	47	37	40				1.25		1.0			
40	47	37	80						0.5			
80	47	37	20				5.0		4.0			
80	47	37	40				2.5		2.0			
80	47	37	80				1.25		1.0			
30	47	37	40		1.25				.75			
60	47	37	40		2.5				1.5		1.25	

Table 2

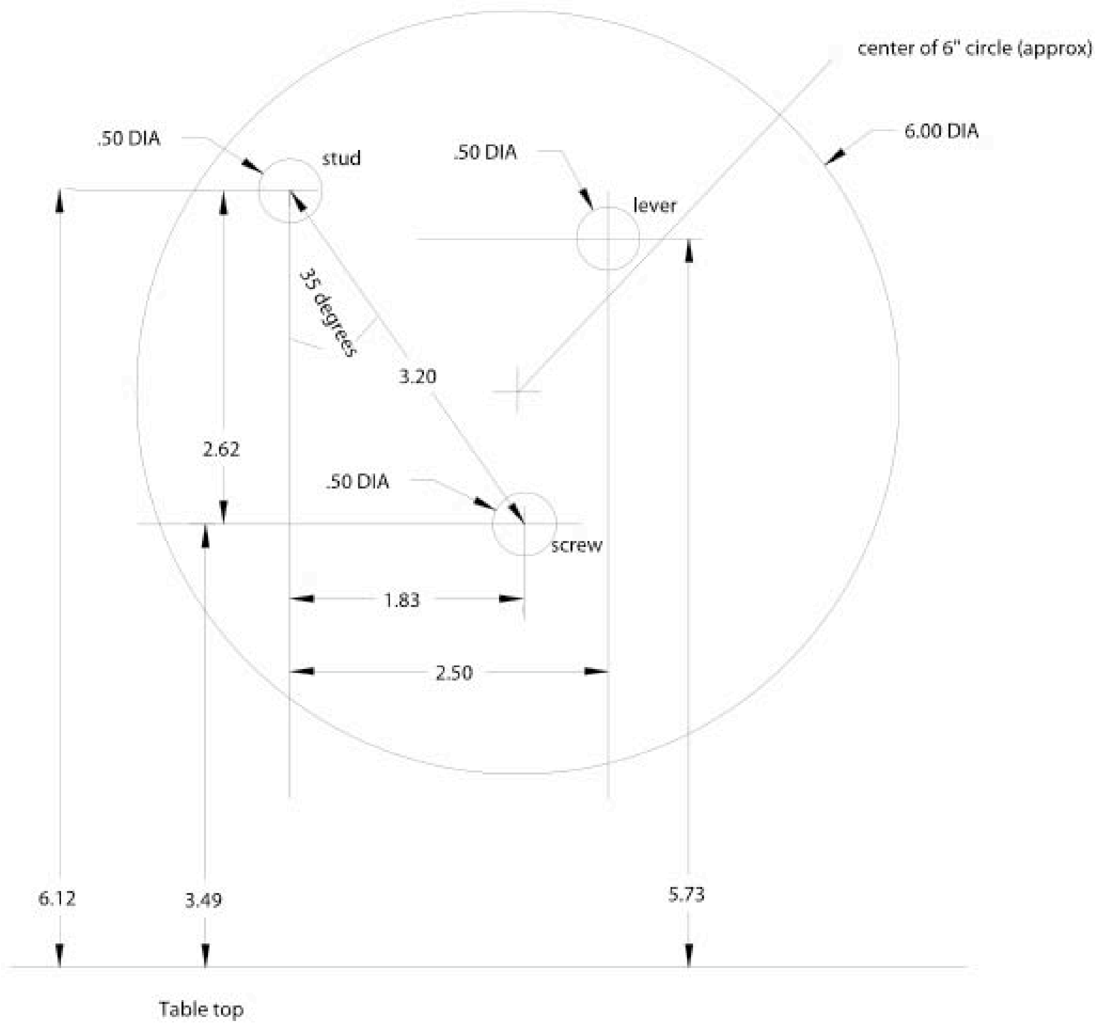


Figure 1: End Frames

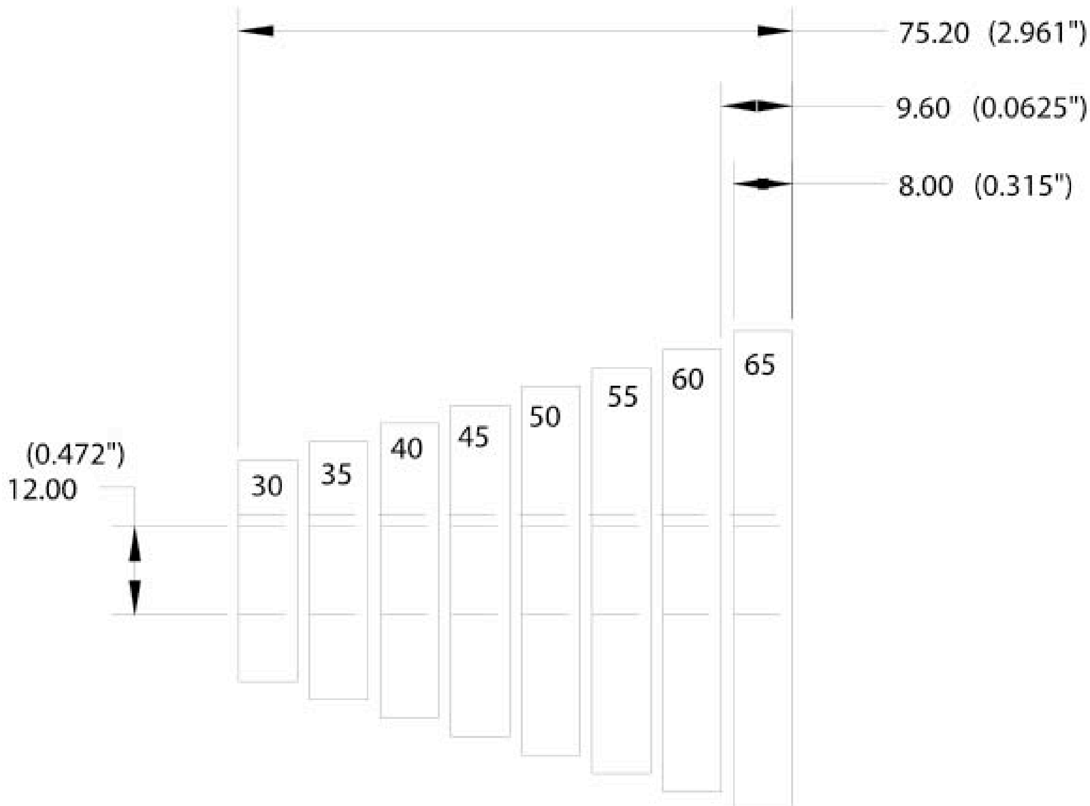


Figure 2: "D" gear group

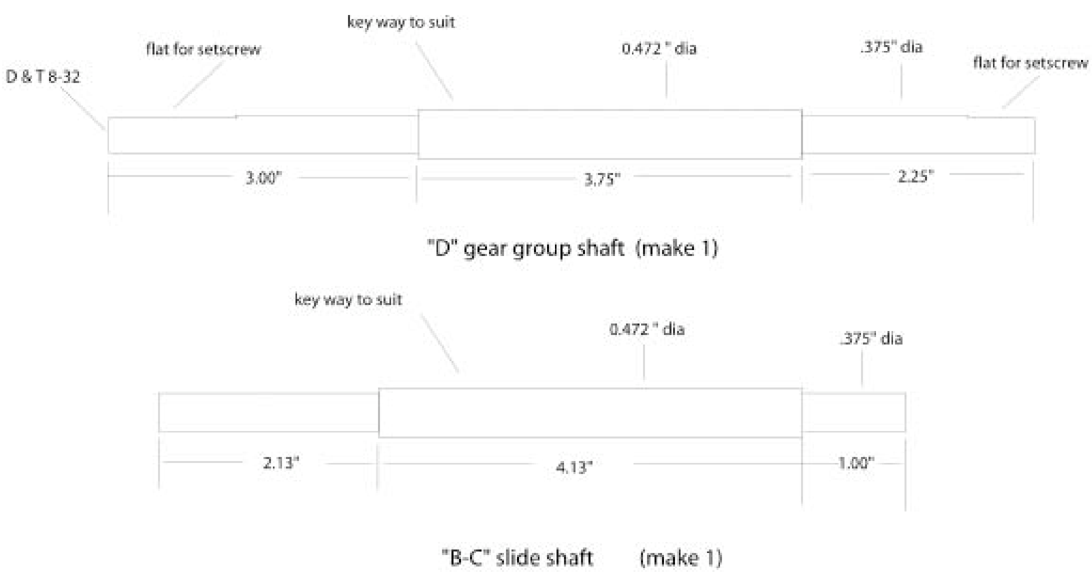


Figure 3: "D" gear group shaft and lever slide shaft

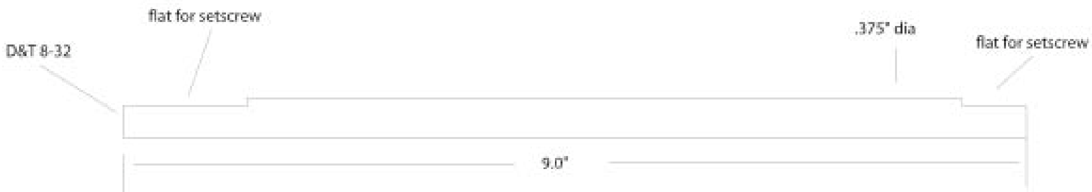


Figure 4: Stud shaft extension

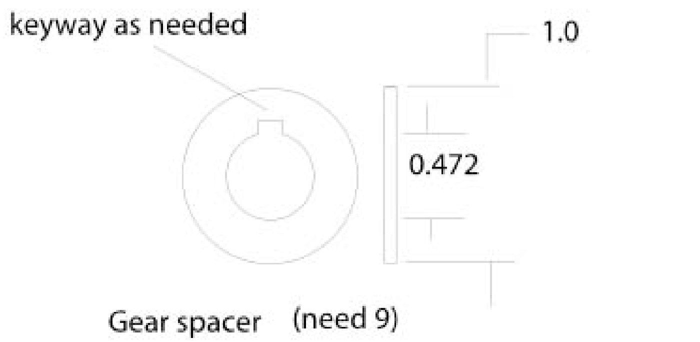


Figure 5: Gear spacer

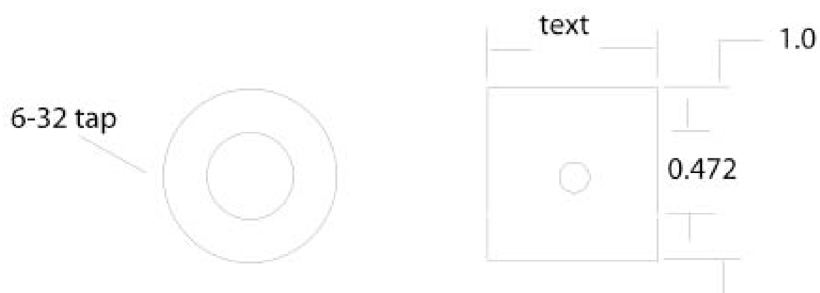


Figure 6: "D" gear end fillers

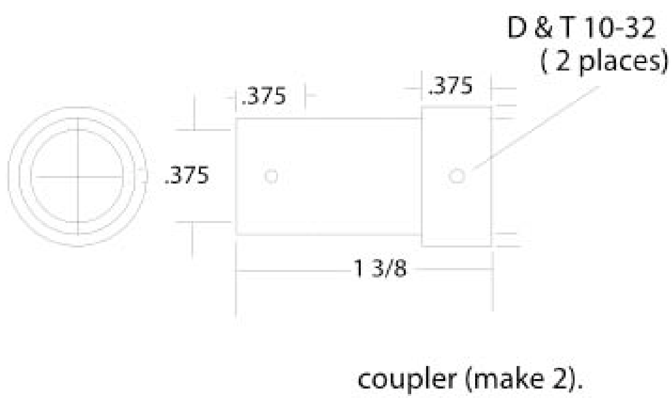


Figure 7: Couplers

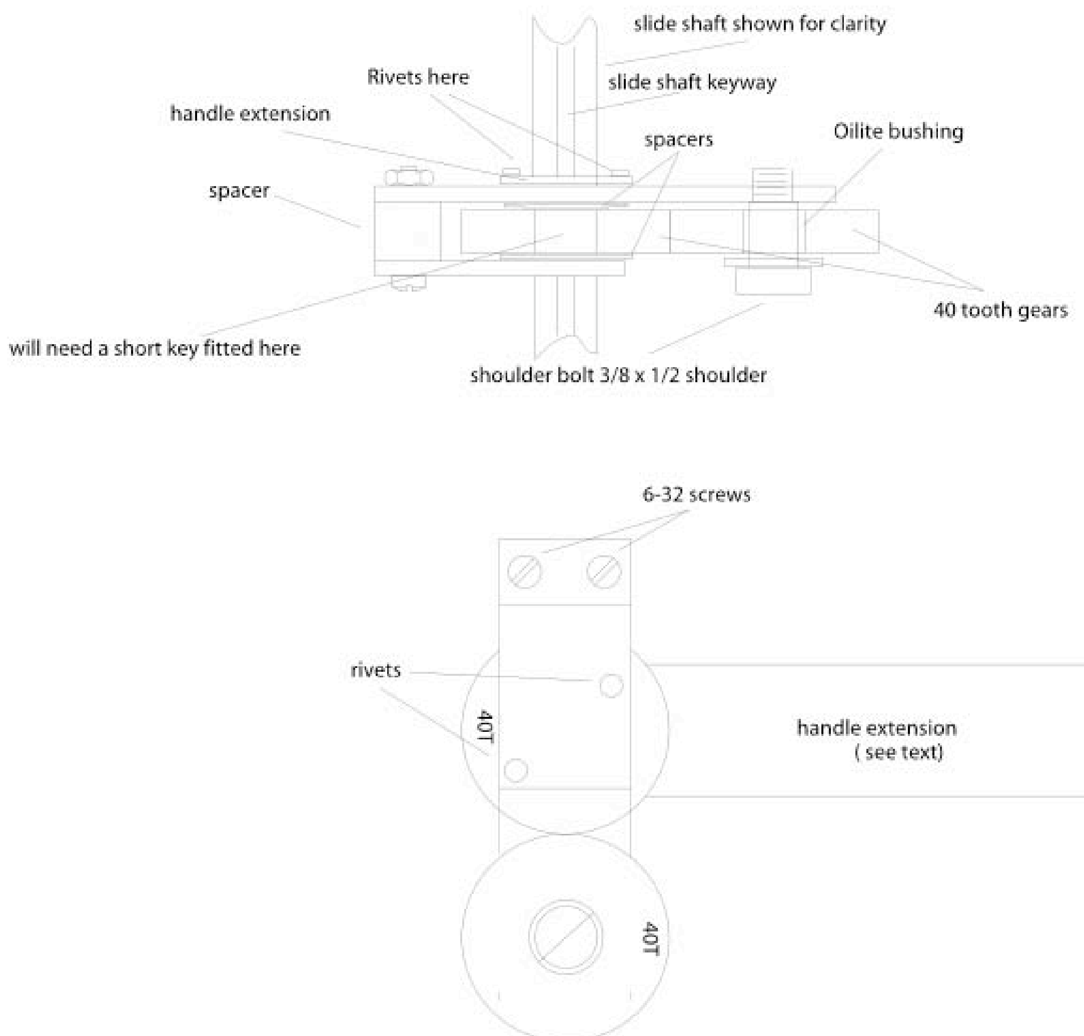
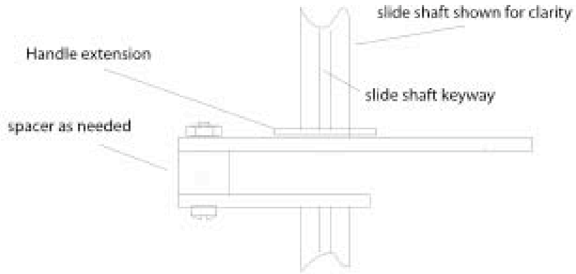
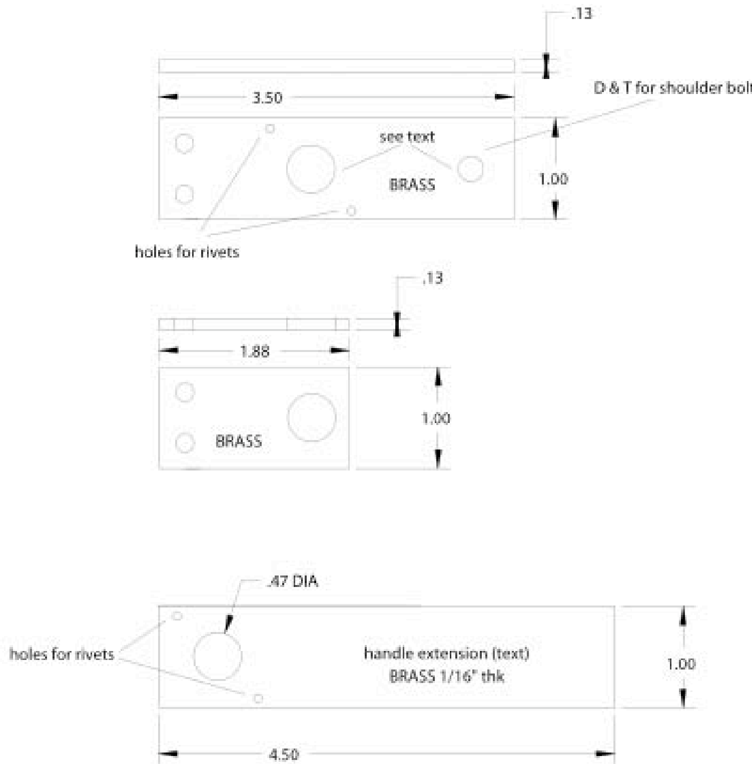


Figure 8: Slide Assembly

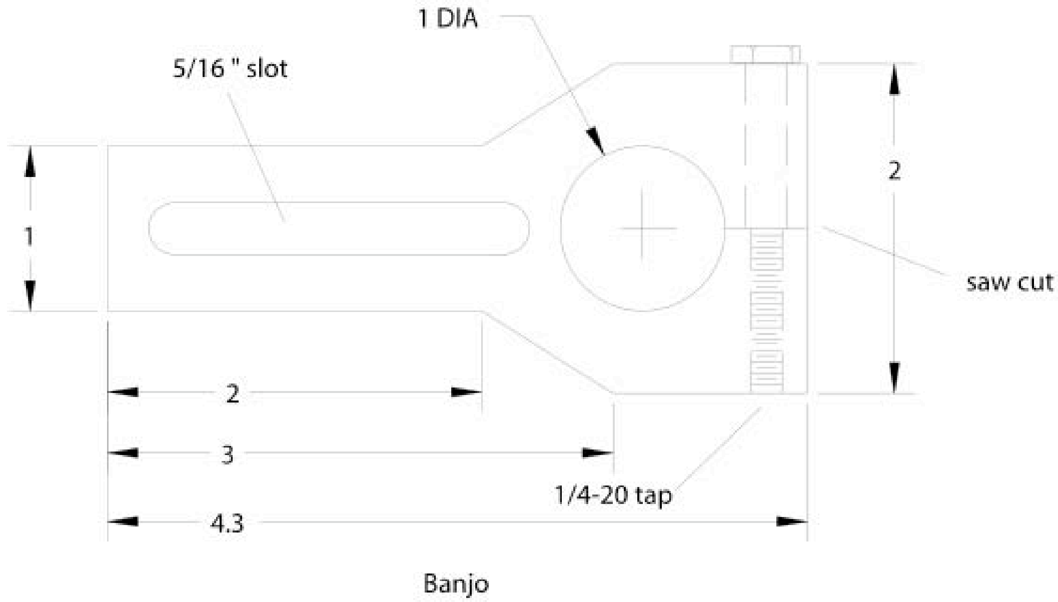


Frame ready to bore for shaft



Slider frame parts

Figure 8A: Slider frame parts



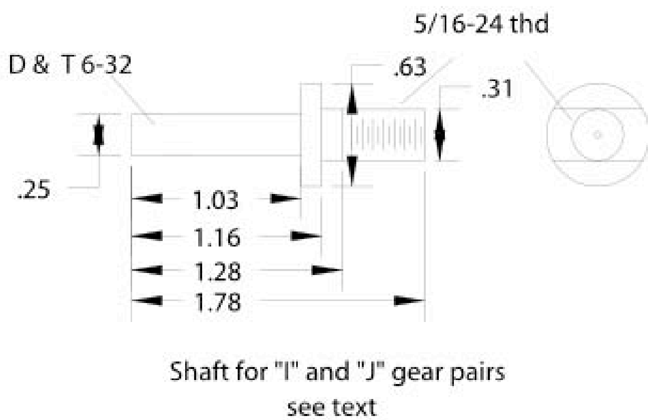


Figure 9: Banjo and Shaft for "I" and "J" gear pairs

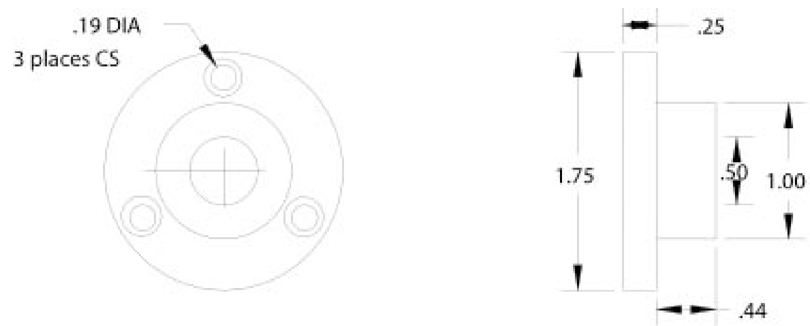


Figure 9A: Journal

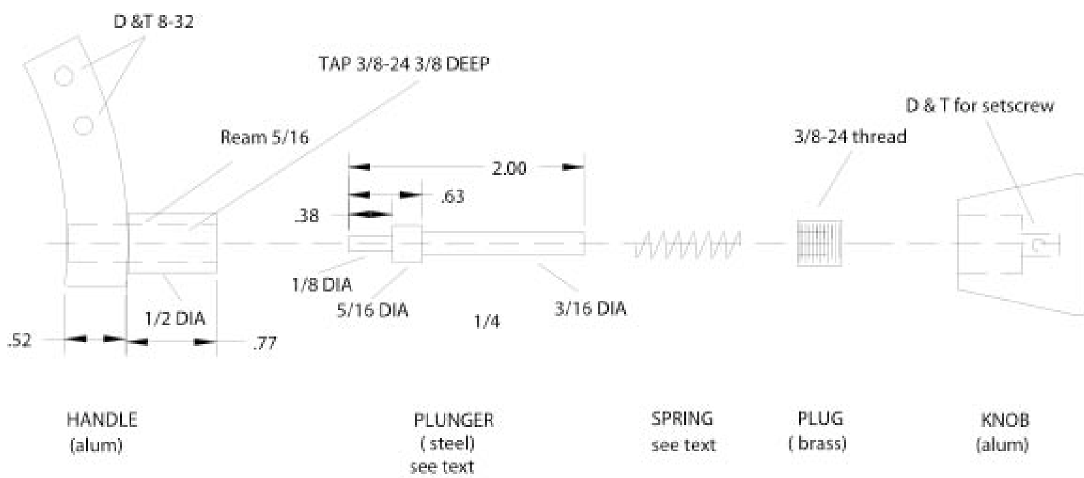
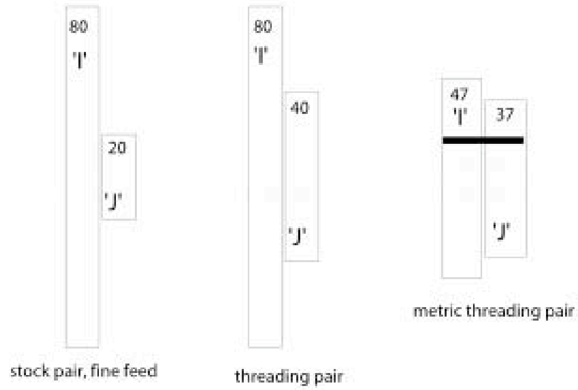
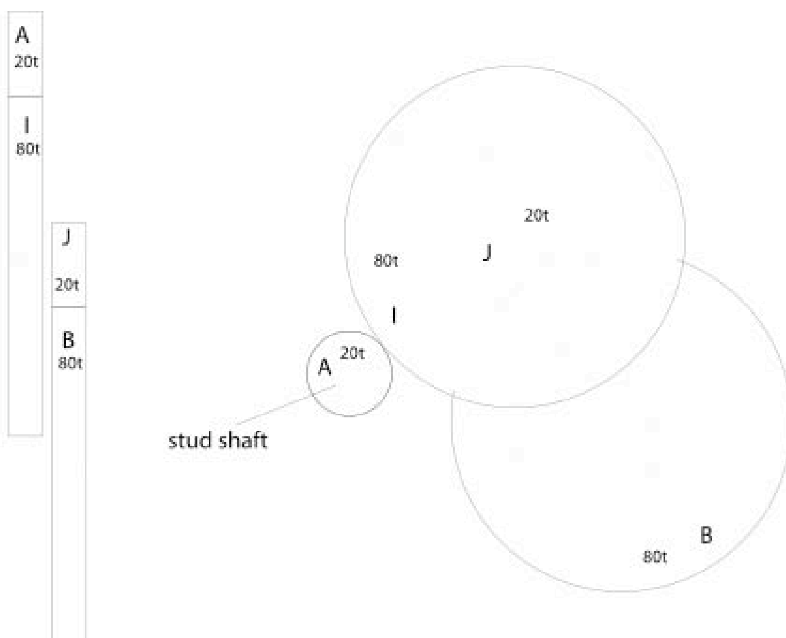


Figure 10: Shift handle



I/J gear pairs



Outboard change gear positions for fine feed

Figure 11: Outboard change gear positions for fine feed

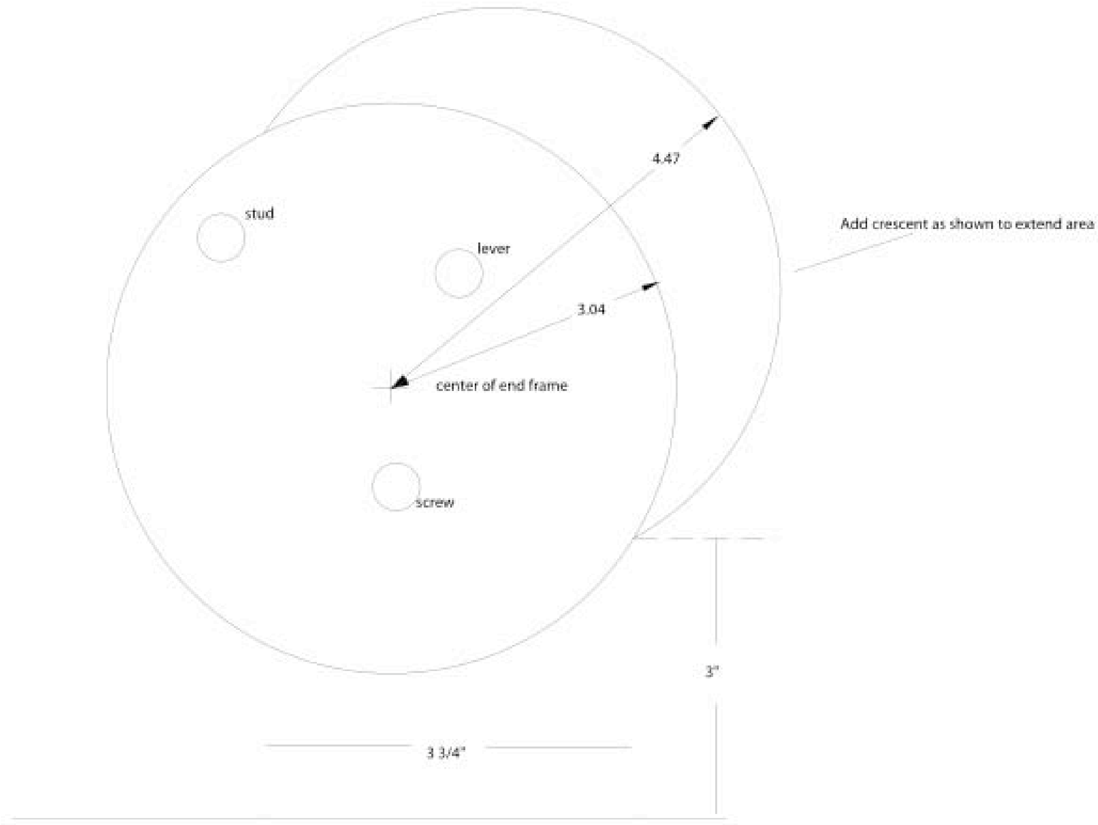


Figure 12: End frame modification

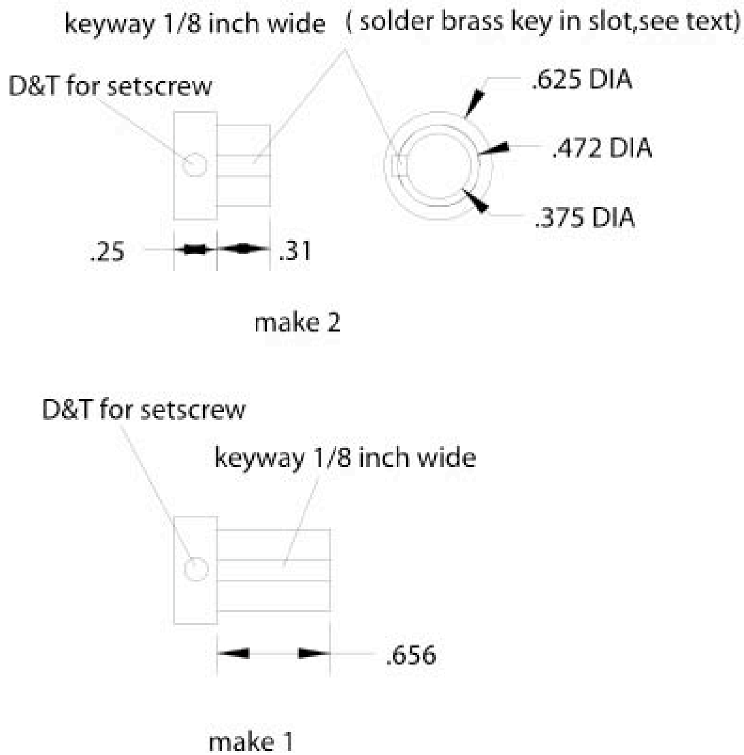


Figure 13: Adaptor 3/8 inch to 12mm

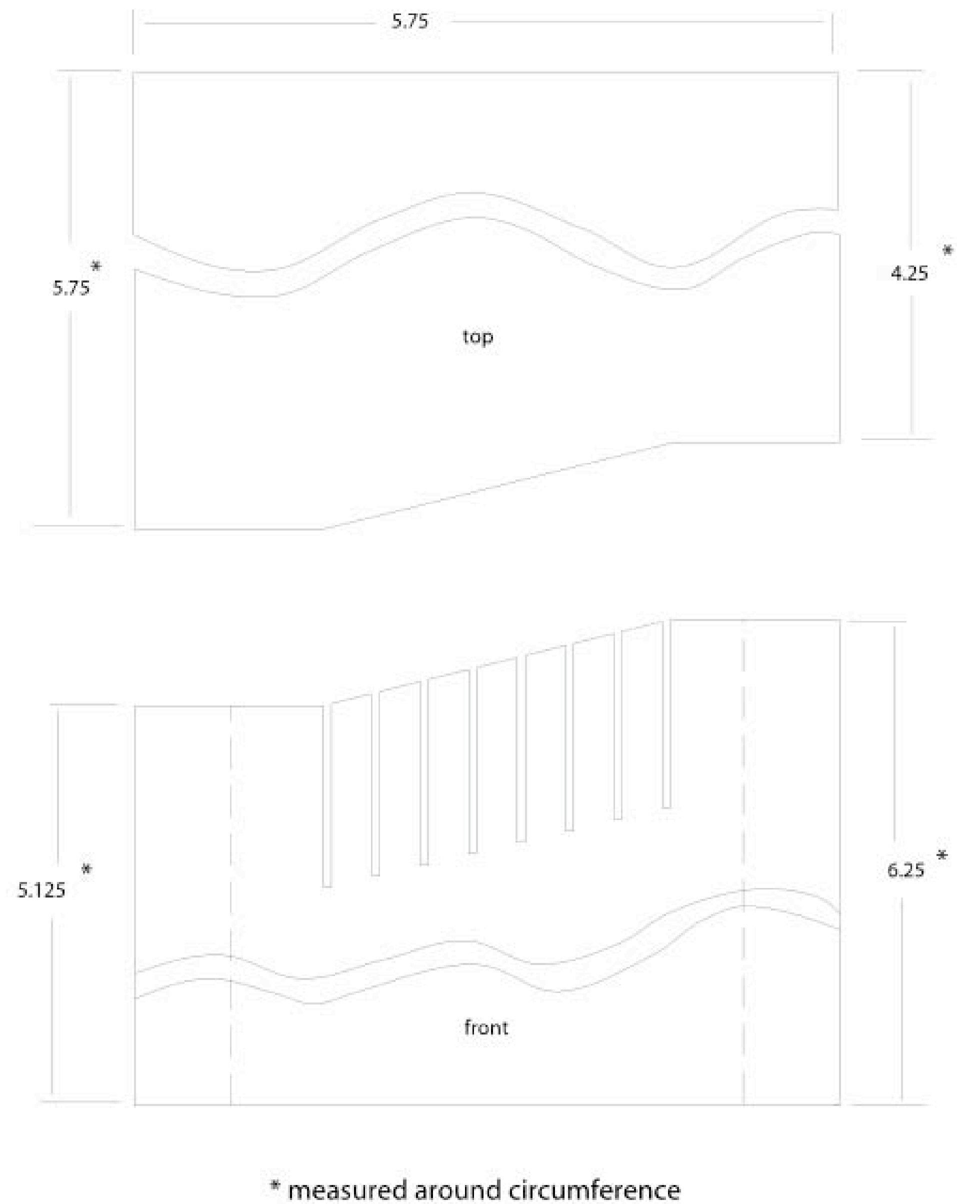


Figure 14: Top and front covers