Dear Tub-O-Tone Buyer/Builder,

Thanks for buying a Tub-O-Tone™ kit. I hope that the instrument gives you many, many hours of musical pleasure, and that the grim business of interpreting and carrying out my building instructions soon appears inconsequential by comparison.

If you have access to a computer, be sure to visit the Tub-O-Tone page, on the Internet at http:// tub-o-tone.com, which now features a section of photos of documenting the construction process. Check there also for news of improvements in the design. The Washtub Bass Page website can be reached via the same address.

As a registered Tub-O-Tone owner, you have life-time tech support, so long as it's on your nickel. I am continually making improvements not only in the design but also in the instructions and the building method, so keep in touch. And please give me your feedback– I'll appreciate it whether it is positive or negative. In the long run, it is the experiences of builders like you that will help me improve the design, or at least avoid dumb mistakes.

Here's my guarantee to you as a registered Tub-O-Tone builder:
If you follow my instructions, and you get in touch with me with any problems you have interpreting the instructions or in the construction process, then if you complete the instrument and find that you are disappointed, just send me a picture of your Tub-O-Tone and I'll send your purchase price back.

I am assuming the builder knows how to use the equipment mentioned, at least to the point of being willing to take responsibility for the consequences of using it. I don't believe that I am setting you up for any harm, but I read recently that a rider was suing a bicycle company for failing to tell him not to ride at night without lights, so I suppose I should just blurt it out: if you manage to hurt yourself with a Tub-O-Tone, I'm not responsible. So be careful, use good judgment, and don't play it in the middle of a busy street at night– at least not without lights!

Plunk in Peace,

Lauren Miller

IMPORTANT NOTICE: If you received your patterns by e-mail or downloading, you must verify that, when printed out, the 2" square shown on several of the Patterns Pages actually does measure 2" on a side. Use the enlargement feature of your printer, or an enlarging/ reducing copier, to adjust the size. For example, if the so-called 2" square is actually 1.75" on a side, set your enlargement factor to 114%, since 2/1.75= 1.14.

Tub-O-Tone™ Materials Shopping List

Item	Description	Reference	Quantity
	(Consult reference for usage or further information)		
Screws			
1. #8 1-1/4"	(All screws are phillips pan-head sheetmetal screws.)		13
2. #8x1"			3
3. #4x3/8"			45-50
Nuts, Bolts and Washers			
4. J-bolts	3/16" diameter 1-1/2" to 2" length	§ II-F, § VII-B	6
5. washers	#8		8
6. wing nuts for same	10-24		6
7. hanger bolts	1/4" x 2"	§ II-E	3
8. T-nuts for same	1/4-20		3
9. nuts for same	1/4-20 for installing hanger bolts		2
10. eye-bolt	1/4" x 3" threads must run entire length of shaft	§ XI-A	1
11. nut for same	1/4-20		1
12. wingnut for same	1/4-20		1
Lumber and Millwork			
13. dowel	7/16" or 1/2" diameter consult § I-C, §VIII-A,	§ III-D	12-18"
14. pine board	1" x 6" x 8' or 1" x 12" x 4'	§ II-A	
15. parting stop	1/2" x 3/4"	§ II-B	5'
16. screendoor trim	1/2" x 1/14"	§ II-B	15-20"
17. stair rail	1-1/2" x 1-11/16" or 1-7/16" x 1-5/8"	§ II-E	15-20"
Miscellaneous			
18. tub	#2 or #3 galvanized-sheet	§ Sect. I	1
19. tool handle	60" hoe or mop handle	§ Sect. I	1
20. aluminum bar	1/8" x 3/4"	§ IX-A	24"
21. aircraft cable	1/16" (7x7) stainless steel (not galvanized)	§ II-F	6'
22. cable stop	for 1/16" cable	§ II-F	1
23. hose clamp	must go to 1-3/4" max. diameter	§ XIII-A	1
24. finial	bicycle brake cable cap	§ XIII-C	1
25. wire	22-gauge steel single-strand or picture wire	§ VI-C	24"
26. "screw-bumpers"	3/4" dia. (or crutch tips)	§ II-E	3
27. nut (plastic pipe)	5/8" section of 1" Schedule 40 pvc water pipe	§ XI-B	1
28. carpet pad		§ II-D	24" x 24"
29. shelf liner	rubberized lacy stuff– not sticky back	§ II-C	12" x 18"
30. center panel	laminate ("Formica ®") or similar	§ II-C	24" x 24"
31. double-sided tape	assuming 1" width	§ VI-C	15-20"
32. felt pads	3/4" diameter self-stick, as for knickknacks	§ II-D	4
33. cellophane tape		§ IV Note 2, § VI-C	
34. spray adhesive		§ III H, I	
35. solvent/lubricant	(WD-40)	§ III A, D	
36. silicone or acrylic caulk		§ XI-C	
37. stick-on dots and/or	4' of pin-stripe tape	§ Appendix One	

The Necessary Tools

Boring and Turning

Slot (regular) screwdriver, medium
Phillips screwdriver, medium (or P2 bit for electric drill)
Phillips Screwdriver, small (or P0 bit for drill)
Drill and Bits: 5/64, 3/32, 1/8, 9/64, 5/32, 7/32, 1/4, 5/16, possibly 3/8
Drill Guide or Press (Optional)
Adjustable Wrench

Sawing

Sabre saw
Small handsaw for use with miterbox
Hacksaw

Dressing

Metal file (flat or 3-cornered)
Four-way wood rasp (shoe rasp)
Sandpaper

Marking and Aligning

Pencil
Felt-tip pen
Awl or ice-pick
#4 finish nail
Center punch
Cold-chisel
Tape measure
Straightedge
Try square
Framing Square (can be improvised)
Miterbox
Dividers (optional)

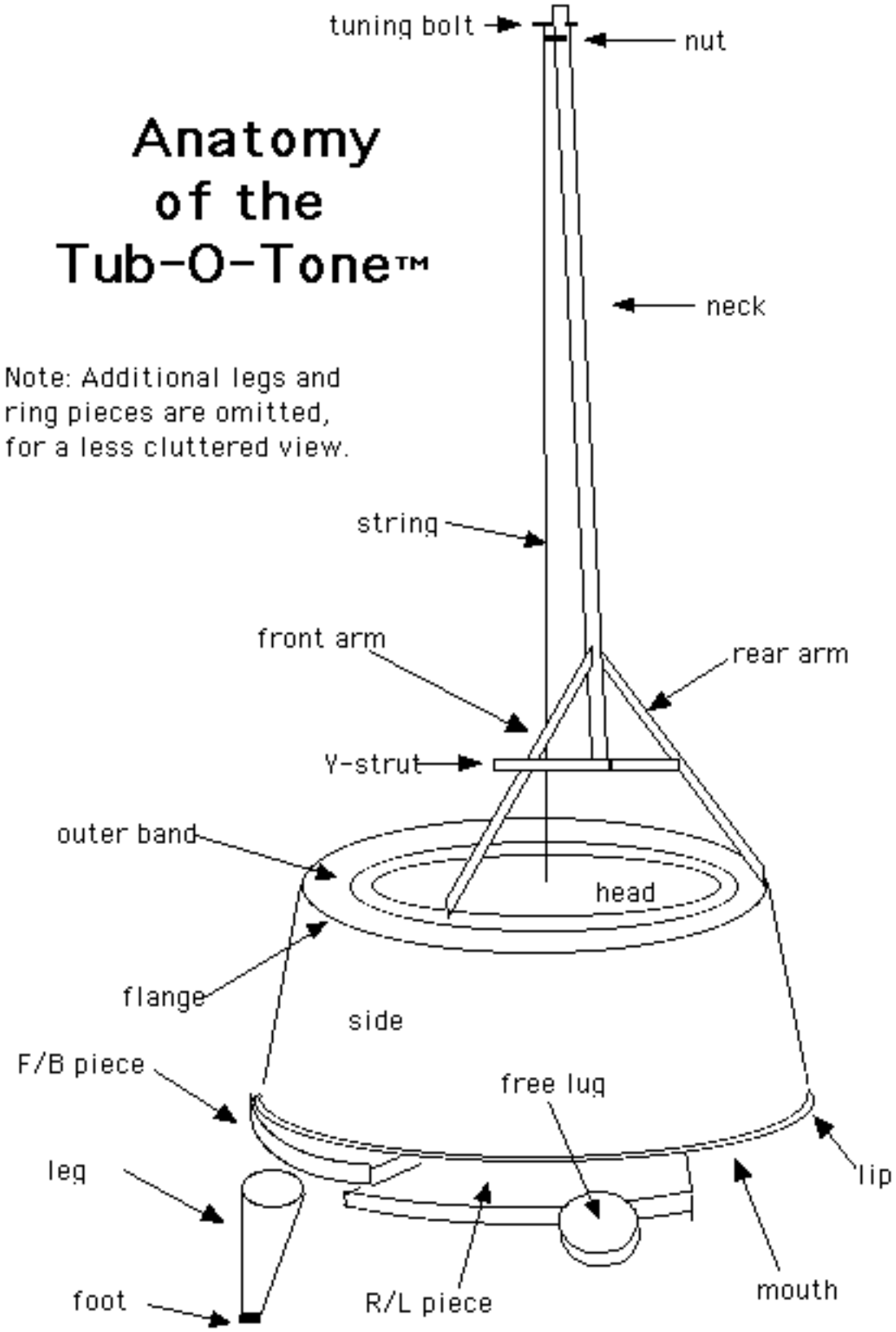
Pounding

Ball-peen Hammer (8- or 12-oz)

Squeezing and Holding

Pliers, Large (e.g. pump pliers)
Pliers, Small
Wire cutters
Spring clamps, small (2)
Vise

Anatomy of the Tub-O-Tone™



Overview of the Manual and the Construction Process

Building a Tub-O-Tone is not a particularly difficult process, but it does involve a lot of steps. What I will try to do here is give you the big picture, so when you are doing some small task you'll know what it's going to contribute to the final outcome.

Section I. This section gives advice about selecting a tub, and a tool handle for the neck.

Section II. Provides details you may find useful in choosing other raw materials. You should review both Sections I and II before heading out with your shopping list.

Section III. We leap right in and prepare the tub for its conversion into a musical instrument. We have to work the metal somewhat with wooden tools and a hammer.

Section IV. The physically hard part is over. Now we cut out wooden pieces to make a back for the tub.

Section V. We assemble the segments into a ring, and screw it together firmly enough to hold its circular shape, but loose enough to allow insertion of a center panel.

Section VI. We fit the center panel into the ring. When this unit is attached to the open back of the tub, it converts it into something like a drum.

Section VII. We make legs for the back ring to stand on, and modify J-bolts to hold the tub to the ring. Now the project is really getting off the ground!

Section VIII. We prepare the mop- or hoe-handle to become the neck of the Tub-O-Tone.

Section IX. We make the components of a tripod for the neck. We always have to work with care, but this is the one phase of the project that calls for precision too.

Section X. Here we're putting the neck together with its tripod. (Unlike other washtub basses, the T-O-T has a stationary neck, which just stands there while you press the string against it.)

Section XI. We add a few components to the neck, and then connect neck to tub with the string.

Section XII. We mount the neck on the tub and make final adjustments in the tripod. Tedious.

Section XIII. Skip the cosmetic stuff for now– let's tune it up and plunk it!

Appendix I. We go back and add a few final practical and cosmetic touches.

Appendix II. Troubleshooting

In the instructions, § identifies any internal reference, and numbers in brackets (e.g. wire [25]) refer to items on the Materials Shopping List.

I. Choosing a Tub and a Neck

I-A Behrens Tubs

The tubs I recommend are the Behrens 2gs and 3gs. The "gs" stands for "galvanized sheet", indicating not hot-dipped. Behrens tubs are sold through the Home Depot hardware chain stores. According to Behrens headquarters, they are also distributed through the True Value, Hardware Hank, Our Own, Coast-to-Coast, and Service Star chains, as well as by Ace Hardware stores in some areas.

The address of Behrens is 471 W 3rd St., Winona, MN 55987; telephone 507-454-4664; e-mail <behrenscs@bresnanlink.net>. They can tell you where to get their tubs in your neck of the woods. Bear in mind that a galvanized sheet tub may cost as much as $10 less than a hot-dipped one– which gives you a little latitude if a special-order is required.

The Tub-O-Tone Two (based on the 2gs tub) doesn't have the range of overtones or the carrying power that the Three model (based on the 3gs) does, but this is not necessarily a bad thing: for playing indoors and/or in especially "live" or resonant surroundings, the Two is even preferable. Because of its more controlled sound, the Two is more manageable in a recording situation, or anywhere indoors where your bass will be miked. And because it is a more well-behaved instrument, the Two tends to be more suitable for playing with smaller, gentler groups. The Three, on the other hand, is both louder and more responsive. I recommend it especially for playing out-of-doors, or with loud groups, or as a melodic solo instrument.

I-B Other Brands and Sizes

If you can't obtain a Behrens tub, try anyway to get a tub made of pre-galvanized metal– not a sturdier hot-dipped model. Pre-galvanized ones are lighter in weight, and look shinier and smoother; on a hot-dipped one you can see the pattern of the zinc crystals on the surface. They'll often have some blobs or runs as well. Check the joint between tub sides and bottom: pre-galvanized tubs are commonly sealed with a line of silicone caulk at that point. At a farm store, the salespeople can probably tell you which tub is which.

The design will work with a hot-dipped tub, although not as well; and it may be necessary to tune it up to a G, rather than to the low E. (My money-back guarantee applies only if you use a Behrens gs tub.)

These instructions assume that your tub will be the size of a 3gs (approximately 24" in diameter) or a 2gs (approximately 22" in diameter), as measured across the opening to the outsides of the lip. If your tub is much more than 1/8" off from these two standards, you can adjust the size of the patterns for the backring side and bottom pieces by using an enlarging/ reducing copy machine. For the tripod dimensions to be applicable without extensive modification, however, the pattern in the top must consist of concentric corrugations with 1" between each ridge and the next, and the outermost ridge 17" in diameter (for a #3 tub) or 15" (for a #2 tub.) In particular, I have not had good luck with the 24-5/8" #3 tub available from some Wal-Mart stores, which has a 19" outermost ridge. And the innermost circular surface should not be more than 2-1/2" in diameter.

NOTE: See § Section VI Note 2 for determining diameter of a non-Behrens tub.

I-C Choosing a Tool Handle for a Neck

You can go two ways for the neck of your Tub-O-Tone. The plain way is a straight industrial mop handle, with a uniform 1-1/8" diameter the entire length. Readily available at hardware stores, they are less expensive and somewhat lighter than hoe handles. The fancy way is a contoured hoe handle, that can be as wide as 1-1/4" near the top, necks down to 1" or so, and gently slopes up again at the business end, typically with a 4" tapered end. I prefer the hoe handle, since it looks better and has a little more mass, but it's hard to find one that's reasonably straight.

The diameter 5" above the business end is critical– it **must** be between 1-1/8" and 1-1/4". (You can measure it with a large adjustable wrench.) Either handle should be 5' long, and may be blunt, threaded, or smoothly tapered at the end. Check for straightness by laying it on the floor and rolling it, slowly, while you watch for high spots and eccentricities. The straighter the better, but perfect straightness is not required.

If it has a metal ferrule, this must not cover more than 4" of the tip, or be removed altogether. Varnished is better than unvarnished (your noting hand moves faster over a varnished surface), and visible grain (e.g. maple) is better than undetectable grain (e.g. birch)– the latter seem to have less ring to them, which affects the sound somewhat.) A hoe handle is often drilled out for the tang of the blade, and this hole must be filled before attaching the strut unit. Choose dowel [13] diameter and length accordingly.

II. Selecting Additional Materials

§ II-A Pine Board [14]

This doesn't have to be #1 clear, but the fewer and smaller the knots, the better, since that gives you more latitude in placing your patterns so as to avoid cutting through any knots. It doesn't have to be perfectly straight, since the longest pattern is less than 20". However, it is important that the board not be bowed across its width. 1"x12" is slightly preferable to 1"x6" since the pieces won't have to cross the heartwood.

NOTE: I have used poplar, cottonwood, maple and red oak. All are more pleasant to work with than pine, and better looking– but the wood in a Tub-O-Tone is not really on display. I have also used a wood substitute (MDF) made of recycled materials. There was no detectable difference in the musical quality of the instrument with any of these materials, and they all add weight– a significant factor if you're going to be lugging your Tub-O-Tone very far. (If you use hardwood for any components, bear in mind that you may need larger guide holes for screws than those specified here.)

§ II-B Pine Millwork [15]

The two front arms and other components of the tripod assembly are cut from 1/2" x 3/4" pine stock (called "parting stop"– standard dimension millwork at a lumberyard.) Look for a piece which is reasonably straight and does not twist, and on which the grain is close and runs parallel with the length.

Screendoor trim [16] is standard millwork available at any lumberyard. It is 1/4" thick and 3/4" wide, with rounded edges on the top and square edges on the bottom.

§ II-C Center Panel [30]

For the center panel of the back, countertop laminate (Formica ®) is effective and simplest to work with. Other materials are capable of giving greater responsiveness combined with a tone which is somewhat more mellow. I have gotten good results with are ABS and polycarbonate, in sheets approximately 1/16" (.0625) thick. Thin plywood “door skin” can also be used.

Companies that make countertops or do custom kitchen installations often have scraps of laminate, for free or cheap. A large hardware chain like Home Depot will often carry 2'x4' sheets at a reasonable price. Likewise, plastics fabricators may have scraps of flat plastic stock, and suppliers often sell sheet stock by the square foot.

§ II-D Carpet Pad, Shelf-liner and Felt Pads [28, 29, 32]

The carpet pad we're looking for seems to be made of millions of little bits of trash foam all glued together. Carpet stores will probably give you a scrap, or at least point you to the dumpster. The shelf-liner is a rubberized sort of lacy mesh stuff, with no adhesive backing. The felt pads are the sort used on knickknacks to protect a varnished dresser top.

§ II-E Legs and Feet [17, 26]

You can make legs from "3/4-round" handrail stock . They’ll need hanger bolts for mounting. Off-the-shelf furniture legs are available. Be aware that they can be difficult to trim to odd lengths.

With legs shorter than 3", you may not be able to get your toe under the instrument, which you may find ergonomically limiting. With legs more than 6", the instrument can get a little shaky. Between those extremes, pick short or tall according to your own height. With three equal-length legs, the instrument will slant slightly toward the back, causing the neck to lean back toward your shoulder in the manner of a standard upright bass, providing a better playing position.

Rubber feet of some sort are essential, so don't waste your money on fancy metal tips or adjustable pads. Thick legs will require a screw-mounted foot (screw-bumper); otherwise you can use crutch tips.

§ II-F Miscellaneous Hardware Notes

String [21]: 1/16" aircraft cable is what you want. Believe it or not, it's very gentle stuff. Don't waste your time with weedwhacker line, clothesline, parachute chord, or "legit" bass strings of any sort. Compared to aircraft cable, they're either unplayable or inaudible. Carefully examine the length to be sure there are no broken strands.

Cable-Stop [22]: For a cable stop, get the kind that is a single little aluminum cylinder, not the double-barreled ones for making loops.

J-bolts [4] : 3/16" J-bolts can have hooks that are 5/8" across or more. You want the 5/8" size, but if you can't find them you can get larger ones and mash them in a vice. Length can be 1-1/2" to 2". Longer ones can be cut back, but threads must start no farther than 1" from the curved end. (Lacking true J-bolts, you might be able to adapt eye-bolts, with appropriate hack-sawing and rebending.)

III. Preparing The Tub

§ III-A Remove Label

Peel off the shiny printed layer of the label as much as you can without scratching down to metal, to give the solvent access to the stickum underneath. Then shoot it with WD-40, allow it to soak, and scrape the label off with a wedge of scrap wood.

§ III-B Remove Handles, Tighten Brackets and Crimp Lip

Anything loose on a tub is going to buzz or rattle, and it'll drive you bonkers. To remove the handles, hold the tub mouth vertical, and clamp the lower corner of a handle in a vice; then use large pliers to unbend the upper corner until the upper end of the handle comes out of the handle bracket. Then slide the tub off the lower end of the handle.

Check the handle-brackets to see if they rattle when tapped. You can remove them, by drilling out the rivets, but it’s easier just to tighten them: press the outside end of a loose rivet against some hard surface and pound the inside end with the ball of a peen hammer.

The lip of the tub is crimped around a wire ring, and this is not always completely firm. To prevent its buzzing at certain frequencies (and to improve the looks), work your way around the ring by 1" intervals, using small pliers to curl the edge of the lip up onto and snugly around the ring. Look out for the gap where the wire ring completes its circle. Don't crimp the lip there, of course, but mark the spot with a bit of tape, since this has bearing on how the tub is positioned on the back ring (see § VII-D.)

§ III-C Prepare the Tub-Conditioning Tools

Sharpen the tip of a 12" section of dowel [13] so that it looks proportionately like a big dull pencil. The point should be a rounded 1/8” or so.

Using the pattern on § Patterns Page 2 (Fig. 2a), outline the Large Tub Tool on your pine board, at one end or maybe in one of the rougher areas. The shape is critical only at the business end (A, B, C). Cut it out and round the edges of the handle end only. Around the business end, just make the edges clear and crisp.

§ III-D Enhance the First Bend

Set the tub mouth-down on a firm surface. Work in a good light so that you can see clearly the First Bend– the line where the Outer Band starts to bend up to the ridge of the outermost corrugation (see § Patterns Page 1, Fig. 1a.) With a felt-tip pen, mark a line around the head right along the line of the bend, to enhance its visibility. Turn the tub often so that your perspective on the point of operation remains the same.

Basically what you're going to do is make that factory bend deeper and better defined. With the point of the Small Tool (dowel), work around the tub an inch or two at a time, following the ink line with only enough pressure to make a slight groove. A squirt of WD-40 on the tip makes it slide easier. Use both hands to control it. Do your best to make the groove single and continuous, with no branches off into the outer band or first corrugation. Then make a second round with heavier bending pressure once you're sure your groove is going in the right place. Rub the point on sandpaper from time to time to remove the build-up of ink and industrial grunge. Watch out if the point binds– that's when it's about to break free and cut a groove where it shouldn't.

III-E Concave the Outside Band

The outermost band of the tub head is usually very ripply, with many convex "bubbles". It needs to be given a definite concave shape, in and down from the flange toward the First Bend.

Put the tub mouth-down on a non-slip surface, where you can see clearly the Outer Band and the First Bend. Rotate the tub often, to maintain this perspective. To work counterclockwise, place the Large Tub Tool on the tub head with curve C on the outer band, flat surface A next to the inner edge of the flange, and the flange curving into and under notch B. This should position the tool at about a 40 degree angle to the tub head.

Press down on surface D, and lift up on handle E, as you move the tool forward, so that curve C gives a concave bend to the Outer Band. Take care that C does not cross into the First Bend. Check the trail of scuff-marks to see what area the tool has covered, and adjust the position accordingly. Expect to apply some serious force in this operation, because you are actually stretching and reshaping the metal of the head.

The Outer Band is never going to be perfectly smooth and concave. There will always some radius creases, with short slightly convex areas between them. So long as these are stable, no problem. But if anything pops back up after you've gone over it with the tool, you must "talk to it" until it decides to stay down.

III-F Convex the Innermost Disk

The innermost circle of the tub head may be either flat or wavy– with some areas dipping in and others bulging out. We want to give it a uniform outward bow (§ Patterns Page 1, Fig. 1a.)

Make sure the Last Bend is well-defined, outlining it if necessary with the dowel point, as you did the First Bend in § III-D above. Then set the tub on a 2-1/4" diameter disk of styrofoam taped to the center, or on a stack of newspapers, thick telephone book, or similar semi-resistive surface. Working from inside the tub, tap carefully with the ball of a light peen hammer to create a gentle outward bow to the middle two-thirds of this inner circle. Tap with a light, glancing blow– i.e., mostly downward, but with a bit of a pull toward yourself and around the circle at the moment of impact, so that the contact motion is more of a slip than a ding.

The first of your taps should be toward the center of the center disk– i.e. into the mouth of the embossed "3" if the tub is a 3gs. Pace yourself– several hundred tiny taps may be required. As the center begins to look concave, widen the target circle somewhat. Turn the tub over occasionally to see that your tapping is having the desired effect. You need not tap closer than about 1/2" from the outer edge of the disk. Do your best not to mash the Last Bend, but if you do redefine it with the point of your dowel.

III-G Punch String Hole

Determine the exact center of the center disk. Working from the inside, with the tub resting on a scrap board, use an awl or ice pick to make the hole. Tap it first just enough to make a dimple. Then hit it harder, but only hard enough to penetrate, since we don't want this hole to be any bigger than it needs to be to let the string go through. Enlarge the hole just by wiggling the awl in it. This leaves a little flared metal around the hole, which can later be bent down against the string to help hold it in place.

III-H Dampen the Sides

Cut two pieces of carpet pad [28], 3" by 24" for a 3gs tub, 3" by 22" for a 2gs. The two areas you want to cover are between the lip and the embossed middle ring, on either side of the back seam, which is the one with a handle bracket riveted across it. Check for correct fit; pad should stay back from the lip about 1/2". Set the tub on newspapers to catch any overspray. Following the instructions for permanent attachment, attach pads with spray adhesive [34]. (Cleaning the metal surface with vinegar or isopropyl alcohol will help the adhesive do its job.)

III-I Dampen the Head

As a deterrent to tinny overtones, we now add a ring of damping material to the inside of the head. Out of the rubberized shelf liner [29], cut curved strips enough to compose a circular ring with an 8-1/2" outer and a 6-1/2" inner radius (for a 3gs tub) or with a 7-1/2" outer and a 5-1/2" inner radius (for a 2gs tub). Sample pattern segments are provided on § Patterns Page 8 and 10; they are about 1/5 of a circle.

Looking inside the tub, you see the target circle as the 7" and 8" ridges (3gs) or the 6" and 7" ridges (2gs) in the bottom of the tub. Lay your liner segments around this circle to make sure you have enough. Trim any excess. Following the instructions for permanent attachment, apply spray adhesive to these ridges down to their adjacent valleys, and paste the segments of your rubber ring around the entire circle.

IV. Making the Ring Components

NOTE 1: The accompanying patterns assume that the large diameter of the tub is 24" (for 3gs) or 22" (for 2gs), to within 1/8". For tubs much more than 1/8" off of these standards, the patterns for the ring pieces (R/L and F/B) and lugs must be changed proportionately, using a reducing/enlarging copy machine. For example, if your tub has a 25" diameter: 25/24 = 1.04 so the patterns should be enlarged by 104%.

NOTE 2: Here's how to determine the design diameter of a non-Behrens tub. Since a tub can get squashed in shipment, we average its diameters. Measure across the tub at several places until you find what seems to be the greatest diameter. Run a piece of tape across the mouth of the tub, at that point. Now find the shortest diameter and compare the two. Adjust the shape of the tub by unsticking one end of the longer tape and squashing the tub slightly before re-sticking the tape. Remeasure. Do this until the two diameters to match, then declare that to be the diameter of the tub.

IV-A Position Patterns on Pine Board

Cut out the ring piece and free lug patterns suitable for your tub size and tape or glue the half-patterns together, with the Orientation Lines aligned and the Outer Edge of one aligned to the Inner Edge of the other. (See § Patterns Pages 4-11.)

Position the patterns on the pine stock to avoid having the curves of the pieces cut through knots. Also avoid including any large or loose or leaky knots in the flat areas. The ring piece patterns are designed to fit on a board as narrow as 5-1/2". If for some reason your board is narrower (or if you have enlarged the patterns– see Note 1 above), then slide the pattern over so that all the outer curve is included in the piece. Trace outlines onto your board for two R/L pieces, and two F/B pieces. Mark a **center line** directly across the middle of each piece.

You'll also need two free lugs, but their patterns are designed to allow them to be cut from the crescent-shaped scrap left when cutting the inside curve of a ring piece, so you may want to postpone them a bit. (Their inner corners Q are not critical and can be slighted if necessary to make the pattern fit the scrap.)

IV-B Cut Out Pieces

Cut out the pieces using your tool of choice: sabre saw, band saw, scroll saw, hatchet, or whatever. Drill no holes just yet. Dress the ring pieces with rasp and sandpaper and look them over carefully. Only the outer curves are readily visible to the general public, and a flawed F/B piece can be put at the back where it's less on display. Both F/B and R/L pieces can be flipped, if there are flaws on the inside curves, to make the best edge of a F/B piece be the lower edge, and the best edge of a R/L piece be the upper (since these edges have to carry the center panel screws.) Decide what's going to go where and mark them F, B, R, and L, on their "tub-sides"-- the surfaces that will be facing up into the tub.

IV-C Drill Guide Holes

Lay out the pieces tub-side up and according to the R/L, F/B decisions you made above. Orient the R/L pattern on the right (R) piece with the T-nut center point within the forward half of the piece, and push your awl through the pattern to mark the point on the piece. Do the same for the left (L) piece. Now lay the F/B pattern over the back piece and push the awl through the T-nut hole position to transfer it to the wood.

Mark points for the inner and outer corner-screw holes at both ends of the front and back pieces, and for the J-bolt mounting holes in their lugs. Also mark points for mounting screws on the two free lugs.

Drill 1/8" guide holes through the pieces at the marked positions. Enlarge the J-bolt holes to 7/32". Enlarge the T-nut holes to a diameter appropriate for your T-nuts (5/16" for 1/4" T-nuts; 3/8" for 5/16" ones.)

V. Assembling the Back

V-A Prepare the Work Surface

The floor is the best work surface for the initial stages of assembly, because you need to look down on your creation from above, to check symmetry and alignment. You'll be drilling holes and running screws, so take precautions to protect the floor.

Place a piece of cardboard or wrapping paper, 30" or so square, over the work surface so you can mark positions. Through the center of this square, and running left to right, draw a straight line for the R/L axis. Perpendicular to this axis, and also through the center, draw a second line for the F/B axis. (See § Patterns Page 1, Fig. 1c)

Around the point of intersection of these axes, draw a guide circle. For a 3gs tub, the radius is 12-1/8". For a 2gs tub, it is 11". For other tubs, make the radius 1/8" larger than half the design diameter of your tub. For example, if your tub is 25" in diameter, the radius of the guide circle would be 12-5/8". If you don't happen to have a compass or dividers that extend that far, then use a long narrow piece of wood: put a small nail through it at one end, and drill a hole big enough to put the point of a pencil through, offset from the nail by the radius distance. Put the nail on the center point and mark the circle by rotating your homemade compass around the center.

V-B Align Right and Left Pieces

Place the two R/L pieces tub-side up on your work surface, with their outer curved edges following the line of the guide circle and their center lines aligned with the primary axis. Check the distances D and D' between the inside straight edges of the two pieces and rotate one (or both) pieces slightly around the circle until they are equal, with centers still aligned as equally as possible to the primary axis**.** Trace the outline of their ends onto your work surface paper, as a precaution against having to do it all over again (see § Fig. 1d.)

V-C Align Front and Back Pieces

Place the front piece in position, spanning between left and right side pieces, with its outer curve aligned to the guide circle and its center line aligned to the F/B axis**.** Slip a scrap of board under it to support it so it lies flat. Adjust it so that its outer curve matches that of the R/L pieces where the pieces overlap. Repeat this procedure for the back piece. Measure the distance between the straight edges of the two F/B pieces and, again by rotating one or both around the center point, make them as parallel as possible. Smooth overlap of outer curves is more important than having parallel pieces, so if you get your smooth curve with a 1/8" deviation from parallel, no problem. When you are satisfied with the positioning of the F/B pieces, use a sharp pencil to mark all pieces where the straight inner edges of the F/B pieces intersect the curves of the R/L pieces. (See § Fig. 1e)

V-D Attach F/B Pieces to R/L Pieces

Holding each F/B piece firmly to the R/L pieces it rests on, and lined up to these marks, extend the 1/8" four corner-screw guide holes through the F/B piece and well into the R/L piece below it. Lift off the back piece, and at the inner and outer corner screw guide holes at either end, run 1-1/4" screws through the piece from the tub-side, until they protrude 1/4" out the other side**.** At the ends of the **front** ring piece, do this only with screws in the **outer** holes. Returning each piece to its position in the ring, align the screw points with the corresponding holes in the side pieces, and tighten all six screws down until both front and back pieces are level but standing away somewhat from the side pieces.

VI. Add the Center Panel

VI-A Determine Radius and Cut Out Panel

Measure the diameter of the enclosed inner circle, in a couple of places. (It ought to be about 17-1/4" with a 2gs tub, 18-3/4" with a 3gs.) Divide the largest measurement by 2 and add 3/4", to get the radius of the panel. Mark a circle of this radius on the (rough) tub-side of the laminate stock [30]. Enhance it with a felt-tip pen so it's clearly visible.

Tips:

* Use your sabre saw, with a hacksaw blade, to cut out the panel.
* If your saw has an oscillating or progressing setting, don't use it– switch to simple up-and-down motion.
* Lay the material colored-surface DOWN on work bench or table.
* Position the sheet so the line you're about to cut is about 1/2" over the edge of the table.
* Adjust the position of the sheet as you cut, to make sure your blade stays close to the table edge.
* Keep the scrap supported until cutting is complete, so that it won't droop and bind the blade, or fall away and snap off a corner.

Mark a diameter across the tub-side of the panel for its F/B axis, and one perpendicular to that for its L/R axis (you can coordinate this to the pattern on the other side, if you're a fnerk for detail like I am.) § Patterns Pages 6 and 8 have guide patterns for marking holes on the perimeter of 9-3/8" and 10-1/8" radius disks. For the best distribution of holes, align a dot of the pattern to a diameter, and make marks for holes 3/8" in from the edge in line with the center and four additional points to each side of the diameter. Drill 3/32" holes at these points.

Make registration marks along both ends of the F/B axis of the panel, at points 1/2", 3/4", and 1" in from the edge of the panel (see § Patterns Page 1, Fig. 1f.)

VI-B Attach Center Panel

Lay the back ring on a flat surface with the tub-sides up. Along the center lines of the two R/L pieces, mark registration points 1/2", 3/4", and 1" in from the inside edge (see § Patterns Page 1, Fig. 1e). Put a scrap of board in the middle of the area surrounded by the ring to help support the center of the panel, and likewise ones sticking into the inner circle from under the front and back pieces. Slip the front edge of the panel, rough-side up, in under the front piece, but on top of the scrap and the right and left side pieces. Then slide it back under the back piece, and align it as evenly as possible to the registration marks. Ideally, the 3/4" marks on the F/B axis of the panel will be aligned with the lower inside edge of the F/B pieces, and the visible edges of the panel will line up with the 3/4" marks on the center lines of the side pieces. It doesn't always work out this way, but more-or-less even overlap all around the circle is all we're really after.

When you are satisfied with the alignment, back off the (outer) screw at one end of the front piece until it sits down firmly on the side piece below it, then tighten it up. Do this also with the (outer) screw at the other end. Run 1-1/4" screws through the inner guide holes of the front piece. Now back out both inner screws on the rear piece, and repeat with the rear outer screws what you just did with the front ones. Finally, run the rear inner screws down tight.

Attach the panel to the right side piece with 3/8" #4 screws in each visible hole. Put one screw through the middle hole on the opposite edge of the panel to hold it in position on the left side piece. Turn the assembly over, tub-side down, being careful not to disturb the relationship of the ring pieces and the panel. Attach the panel to the front and back pieces with screws through the two lines of holes which are now visible, flip the assembly one more time (tub-side up), remove the single screw in the left piece just in case there is any accumulated bulge, and then attach the panel to that piece with 3/8" #4 screws.

§ VI-C Brace and Dampen the Center Panel

Without a stiffener on the center panel, your instrument is likely to make an unmusical flapping sound on certain notes and especially at loud volumes. To avoid this, we adda crosspiece to make the panel vibrate as a unit, plus a panel of damping material.

From the length of screendoor trim [16], cut a piece 3" shorter than the inner diameter of the ring. This piece is the pressure strip. On the centerline, drill 3/32" guideholes 1/2" and 3/4" in from each end of the piece. On the tub-side of the panel, center the pressure strip along the F/B diameter, and mark where the ends lie, on the panel. Cut double-sided tape [31] to cover the length of the pressure strip. Leaving the backing on one

side of the tape, stick the other side to the bottom (unbeveled) surface of the strip. Remove all the backing from the tape. Align the strip to the guide marks, and press the pressure strip onto the panel.

Extend the outermost end holes in the strip through the panel. From the (smooth) outside of the panel, run a 3/8" #4 screw up through each hole and tighten. On the tub-side, carefully screw a 3/8" #4 screw into the innermost end holes, down to but not through the panel. The head of the screw will stick up above the strip.

Cut the wire [25] 6" longer than the distance between these two screws. Wrap one end around one screw and then around itself to form a snug loop. Pulling the wire very taut, loop the other end around the other screw and form a similar snug loop at that end. Trim off any extra wire. Cut a scrap of 1/2" x 3/4" to a 1" length, for a tension block.

The tension block goes at the center of the strip, squeezed between the wire and the strip. The objective is to create a just enough tension to let all areas of the back know that the preferred shape is a downward bow. Too much tension will cause problems of its own. Begin with the block on its 3/4" side, 1/2" high. Next try it on its 1/2" side, 3/4" high. This should give you some feel for the right height; but cut-and-try is the only way to tell for sure. More than 1" of height should be unnecessary. Once you've determined the right height, cut a slight notch across the top of the block for the wire to sit in. Fold a strip of cellophane tape along each of the two spans of wire to eliminate their tendency to vibrate.

Finally, cut a 7.5" radius semi-circle of carpet pad and use spray adhesive to stick it to the tub-side of the center panel, parallel to the pressure strip.

VII. Tentative Assembly and Positioning Free Lug Bolt Holes

§ VII-A Prepare and Attach Legs

Cut lengths from the stair-rail stock according to the suggestions in § II-E. To install hanger bolts [7], drill a 1/8" guide hole in the center of one end and enlarge it to 7/32". Turn a hex nut onto one of the bolts about 1/2", then follow it with another nut. Tighten the second against the first jam-tight. Use a wrench on the outer one to screw the entire wood-screw portion of the bolt into the leg. Then back off the outer nut and remove both nuts. Drill a short 1/8" guidehole in the other end, and attach a screw-bumper [26].

To attach a leg, position a T-nut [8] teeth-down over its hole on the tub-side of the ring, push the leg bolt through the hole from below and turn until it engages with the T-nut. Continue tightening to draw T-nut teeth into wood. Similarly attach the other two legs.

§ VII-B Prepare J-bolts

The J-bolts [4] hook over the lip of the tub to hold it to the back ring. The length of the straight section of the tip probably will have to be reduced to allow the curve of the J-bolt to rest on the lip, without contacting and bending the side. (See § Patterns Page 1, Fig. 1b.) Tighten the straight section of the tip into a vice, with threaded shaft vertical and to the outside. Make the cut with a hacksaw, then dress the new tip with a file.

VII-C Add Free Lugs to Ring

Center a free lug over the notch in one of the R/L pieces and align its outer curve to the curve of the piece so far as possible. (If the lug overshoots the side piece somewhat, this can be knocked back later with a rasp and sandpaper.) With a 1/8” bit, extend its mounting holes down into the piece below. Drill out guide holes in lugs to 5/32”. Then attach the lug with 1-1/4" screws.

§ VII-D Install J-bolts and Attach Tub

Set the completed back upright on its newly attached legs and insert J-bolts in the holes in the four F/B lugs, hooks up and facing outward. Place a washer on the threaded ends below each lug and start a wing nut onto each bolt a few turns, but don't tighten.

Set the tub on the back assembly with the back seam aligned to the middle of the back piece. Pull the J-bolts up and turn them to hook over the lip of the tub. Sometimes the gap where the ring inside the lip comes together will end up right under one of the J-bolts. (You may have spotted this gap during the crimping operation in § III-B.) If it does, rotate the tub slightly, so all J-bolts will tighten down on solid ring. Put a mark on the tub in line with the middle of the back bottom piece. This mark will be referred to as the Very Back.

VII-E Determine J-Bolt Location for Free Lugs

If the tub seems loose between the bolts, squeeze it a little side-to-side and tighten the J-bolts to hold it in position. When it is snug against its J-bolts, use a sharp-pointed pencil to trace the outline of the lip on each of the free lugs. (One function of the free lug J-bolts, is to make the tub sit snug next to all its other J-bolts.) Loosen the J-bolts, remove the tub, and mark the center of each free lug just outside of the outline of the lip. Drill a 1/8" guide hole at this point and enlarge it to 7/32". Add J-bolts to these two new holes.

VIII. Preparing Neck

§ VIII-A Fill End Hole (if there is one)

If the tool handle has a hole up the bottom end, plug it with a length of dowel. Such holes are commonly 7/16" or 1/2". Probe the hole to see how deep it is, and start with a dowel 1/2" longer than the hole is deep. Whittle and sand until it fits in fairly snugly for at least a couple of inches, then pull it back out and reinstall it, liberally coated with glue and with a toothpick or similar wooden shim alongside for tighter fit. Saw off the excess even with the end of the handle.

VIII-B Drill Guide Hole for Neck Screw

Carefully mark the center of the end of the neck and drill a 9/64" guide hole up the end for a couple of inches. Right up the center line is nice, but not absolutely essential. If there’s nobody handy to eyeball it for you, you can shove the far end of the handle into a corner of the room, and press your drill bit against the center point at the other end. This lets you feel it if your bit is too far out of line with the center line of the handle.

VIII-C Mark Front, Back and 5" Line

Examining the neck, notice the grain of the wood. The closely-layered edge of the grain wants to run up the front and back of the neck; the long oval grain patterns will go on

the sides. When you have determined what will be the front of the neck, mark it with a precise line at the edge of the bottom of the neck, and directly opposite that, mark the back of the neck. Finally, make a pencil line around the back half of the neck, at the 5" level.

VIII-D Drill Hole for Tuning Bolt

Up at the top end of the neck, notice where the curve of the tip straightens out and/or blends in to the line of the sides. Slightly down from this diameter (i.e. within an inch or so of the end) is where the tuning bolt should go. Lay the neck down on its back, and with the awl mark a point on the center line of the front. Drill a 1/8" hole directly across the diameter of the neck, then enlarge it to 1/4".

IX. Making the Strut Unit

§ IX-A Prepare the Y-struts

Cut out the 120-degree angle protractor on § Patterns Page 2 (Fig. 2c) and paste it to a piece of light cardboard. Trim the edge of the page along the outer edge of the Y-strut centerhole pattern § Patterns Page 4 (Fig. 4a.)

Cut the aluminum bar [20] into two 12" lengths. Use a try-square to make a mark squarely across each strut at the 5"/7" point. Place the strut hole pattern over each piece, aligned to the 5/7 mark on the bar, and transfer hole centers to the bar by tapping a sharp awl through the pattern. Drill 1/8" holes at all center points, on both bars.

Clamp the first piece perpendicularly in a vice, directly along the 5/7 mark, with the 5" end down, and the 7" up. Check the perpendicularity with your try-square. Bend the bar by applying pressure to the long end while at the same time pounding with a light hammer, at a point about 1.5" above the 5/7 mark. As the bend progresses, pound closer and closer to the mark. Compare frequently with the 120 degree angle to get a precise match. Bend the second strut the same way. When both struts are bent, compare struts and angle, and adjust until all are identical.

IX-B Cut the Wooden Components

The entire strut unit (Y-struts, spacer bar and crossbar) is the same for both #2 and #3 tubs. Only the length of the arms is different. Cut two front arms and a rear arm to the length appropriate for the size tub you are using, consulting § Patterns Page 3. Mark a center point (B, B') on the outside of each front arm, 7-1/2" away from the end hole center point. Do not drill. Drill 1/8" guide holes at the end screw locations but do not enlarge. Cut the spacer bar to 4-3/8", and drill a 1/8" guide hole for the neck screw 9/16" from the end.

Cutting the crossbar may be a bit tricky, since the typical miterbox does not have a 30-degree angle setting. Here are some shade-tree techniques:

* an adjustable-angle box (see § Fig. 3a) will usually have a large gap in the back wall. If yours doesn't allow a 30-degree setting, cut a wood block to a precise 90-degree angle and clamp it to the box. Then use the 60-degree setting for the cut.

* with a fixed-angle miterbox (see § Fig. 3b), first cut the crossbar stock to 8". Place one corner to the inner edge of the 45-degree slot in the back wall. Then position a 3/4" spacer (square-cut scrap of 1x6) between the stock and the back wall of the box, at a point (A') 2-7/8" from the tip. Cut. Cut the opposite end in a similar fashion.

IX-C Assemble Strut Unit

Lay out the Y-struts, crossbar and spacer bar on top of the outline on § Patterns Page 2 (Fig. 2b), and adjust until you have an exact match. Clamp the Y-struts to the spacer bar with a spring clamp. Make guideholes in the spacer bar by drilling through the tail holes with a 5/64" bit, and attach both Y struts with 3/8" #4 screws.

Position the crossbar at the end of the spacer bar, between the Y-struts, and mark crossbar at centerline of spacer bar. Drill a centered 1/8" guide hole across the crossbar in line with this mark, then align crossbar firmly to the center of the spacer bar and extend the guide hole into the spacer bar. Enlarge the hole in the spacer bar end to 9/64”. Enlarge the center hole in the crossbar to 5/32" and the neck screw hole in the spacer bar to 5/32". Attach the crossbar to the spacer bar with a 1" #8 screw.

Holding one end of the crossbar firmly to its Y-strut, poke a guide hole into the crossbar end and attach strut to crossbar with a #4 3/8" screw. Repeat for other side.

X. Attaching Strut Unit and Arms to Neck

X-A Attach Strut Unit to Neck

Run a 1-1/4" screw up from the bottom through the hole in the spacer bar, all the way plus a few more twists until it turns freely in the hole. Now back it out until just the point is protruding, and start the point into the guide hole in the end of the neck. Run it on in but align the unit, with Y-struts equally on either side of the front line of the neck, before final tightening.

X-B Orient and Attach Front Arms

Lay the neck down and support it (or clamp it to your workbench) so that it the back line faces straight up . Make a mark on the strut unit directly in line with the back line. Attach each front arm to its respective Y strut with a #4 screw through the far hole of the strut and into the arm at point B or B' as determined in § IX-B. Note that the arms go in front of the Y-struts and the bevel of the upper ends lies in line with the neck.

Rotate one arm so that the upper end lies flat against the neck and the guidehole lies on the 5" line. Put a small finish nail through the hole in the arm and tap it to mark the neck at this point. Turn the arm away and at the mark drill a 9/64" guidehole like a radius directly toward the center of the neck.

Enlarge the hole in the arm to 5/32". Place a #8 washer on a 1" screw and turn it into the end hole until it points out the other side 1/4". Set the point into the guide hole, then back out the screw until the arm lies flush against the neck. Then firmly retighten the screw. Repeat the process for the other arm and Y-strut.

X-C Temporarily Position Rear arm

Slide the rear arm between the extended tails of the Y-struts, with the upper (notched) end snugged into the intersection of the front arms, and the curved surface firmly against the neck. Hold it in this position with a spring clamp on the tails beyond the arm.

XI. Completing and Mounting Neck

§ XI-A Make and Install Tuning Bolt

With the eye bolt [10] lying with the eye flat, file a small (1/8") flat spot on the bolt, about 3/16" below where the shaft starts to curve into the eye, and parallel to the plane of the eye. The purpose of this flat spot is only to let you drill a hole through the bolt, so its size is irrelevant so long as you can now dimple it with a center punch. Center the dimple on the bolt as precisely as possible. At the dimple, drill a 3/32" hole through the bolt (for the string to go through.)

The bolt needs a “hilt”, to keep the eye from pulling into the neck. With a cold-chisel (or cheap screwdriver) mangle the next two or three rows of threads right below the flat spot of the string-hole, and run a 1/4-20 nut up the shaft until it stalls on these destroyed threads. If it doesn’t stall, back it off and mangle harder.

This hilt nut needs to go right up to the bottom of the flat spot. This should require some significant force, and I recommend that you NOT hold the eye in a vice (which would risk its being twisted off.) Instead, as the nut approaches the mangled threads, hold the bolt with pliers just below the nut and use a wrench to turn the nut into position.

Slip the hose clamp [23] over the top of the neck and let it drop, for now. Put the tuning bolt through the hole in the neck with the eye toward the front of the neck. It should turn freely in the hole– i.e. not thread in or want to tighten. Spin the wingnut [11] onto the opposite end of the bolt, loosely for now.

§ XI-B Make and Install Nut

The nut, over which the string passes at the upper end of the neck, needs to be a strip of something hard but not metallic, that will conform snugly to the curve of the neck when the hoseclamp is tightened around it. Saw off a 5/8" segment of pvc pipe [27] and then cut out a quarter of the circumference. Smooth the edges with a file, then snap it over the neck at the slenderest point and slide it up to 1/2" or so below the tuning bolt.

§ XI-C Prepare and Attach String

If your aircraft cable [21] has ragged or frayed ends, recut them square and clean with a pair of sharp wire cutters. It helps to hold the cable end in a vice, pressing from the sides, while your cutters attack from top and bottom. Coat the newly-cut tip of your string with silicone or acrylic caulk, to help keep it from unwinding.

Slip the cable stop [22] over the end of the cable about 3/4". Lay string and stop on an anvil or other hard surface and with a hammer flatten the stop to secure it to the string.

Cut a 1" disk from a plastic milk jug and stick one of your felt pads [32] to it. With the awl, poke a center hole **through the pad** and then on through the plastic. Thread this, pad-side down, onto the string and slide it down to the cable stop.

From inside the tub, thread the string through the hole in the center. Slip it through the hose clamp slung around the neck and carry the end on up to pass through the hole in the tuning bolt several inches. Slide the clamp up over the nut and tighten it just enough to hold the string to the nut.

XI-D Mount Neck on Tub

Set the neck assembly on the head with rear arm pointing toward the Very Back. Position the Y-struts symmetrically on either side of the string-hole. Pull the entire neck assembly back so that the bottom end of the rear arm touches the flange and the front-arm tips rest in the First Full Valley (see § Patterns Page 5, Fig. 5a.)

Loosen the hose clamp and pull the end of the string to take up any slack. Still holding the end to make sure the string does not pull back through the tuning bolt, turn the bolt clockwise to start tightening the string. (The string does not have to wrap around the bolt to engage with it, so you don't have to start turning the bolt before the string is already hand-tight.) Create just enough tension to make the string run straight. Tighten the wingnut on the threaded end of the tuning bolt to pull the hilt nut against the neck and hold the bolt in position.

NOTE: To remove the neck from the tub without loosening the string, lift the tip of the right front arm and get your fingers under it to avoid its scraping the tub. Pivot the neck assembly on the tip of the left front arm, rotating the right arm clockwise while simultaneously tilting the neck progressively forward. (It may be helpful also to pick up the rear arm with the other hand, to make sure it swings clear of the tub flange when you tilt and rotate the neck assembly. The same applies in replacing the neck, once you have the pivot arm positioned on top of the tub head.)

To reinstall: lean the neck assembly forward, and place the left front arm tip in the First Full Valley and about two inches more than halfway across the tub from back to front. Pivot the assembly on this tip, rotating it counterclockwise while simultaneously standing the neck more and more upright. When all armtips are in their appropriate valleys, rotate entire neck assembly to correct front-to-back orientation.

XII. Making Final Adjustment of Neck

XII-A Set the Action and String Angle

Now for the really fiddly part. The instrument will produce its best sound if the **string** is perpendicular to the tub head, even though this means the neck will lean forward a bit. And it will play best if the “action” (the distance between the string and the neck, as measured right above the upper ends of the front arms) is somewhere between 1-1/2" and 1-3/4". As fate would have it, both these factors depend on the length and angle of the rear arm, so we’ll be making lots of small cuts and doing lots of checking, to optimize the settings without ruining too many sticks of parting stop.

It is easiest to do all this with the tub sitting flat on the floor. And, you’ll need a framing square or reasonable imitation of one. You can make an acceptable substitute by duct-taping a nice straight yardstick to the long arm of your try square. You’ll also need a narrow slat or piece of channel long enough to reach across the tub from flange to flange.

With the neck in position on the tub and the string tight enough to be straight, check the action and adjust the angle between the rear arm and the rest of the tripod to get it close to 1-1/2". Make sure the top of the rear arm stays up against the neck and against the bottom sides of the front arms, and that the bottom corner is up against the flange. Clamp the tail pieces **behind** the rear arm, to hold it firmly in that position.

This will probably cause both neck and string to lean forward. How much, is the question. Lay the slat across the tub, from front to back and right next to the string and the rear arm. Stand your square on it, right alongside the string and with the corner exactly even with the string. Now, looking at the 24" mark, measure the amount that the string slants forward or backward from the perpendicular.

If the slant is more than 5/16" beyond vertical, then remove the rear arm (you can rest the tails on a piece of 2x4) and trim 1/8" of the bottom end, parallel with the bevel (see Rear Arm pattern on § Patterns Page 3.) Reposition, reclamp, and remeasure the tilt and the action. If the action is within 1-1/2" and 1-3/4", and the string is only 1/4" out at 24", you could leave it at that and nobody'd ever know. Or, skip the next paragraph and go on. But if the string is still 5/16" or more out, here's what to do:

If the action is 1-5/8" or less, you can take off another 1/8" as above. Reposition, reclamp, remeasure, etc. If the action is already more than 1-5/8", you should instead cut 1/8" off the rear arm tip **perpendicular** to the bevel (see Rear Arm pattern), which will rotate the string back without adding much to the action. Now, mark my words, you could leave it at that. But if you really want to dial it in, here's how to do it:

To bring the string angle still further back with a slight decrease in action, loosen the clamp and rotate the rear arm up slightly relative to the tail pieces. Or, if it seems you've gone too far, and need to rotate the string forward again, with a slight gain in action, rotate the arm down slightly relative to the tails. Reclamp, reposition. You could remeasure, at this point. But you're probably ready to go on. I know I am.

XII-C Screw Tail Pieces to Rear Arm, and Rear Arm to Neck

When the action and the tilt are like you want them, remove the neck from the tub. Find the center of the area of overlap between rear arm and tail pieces, both right and left. Mark these centers, make a dimple with the awl, and drill 1/8" holes just through the aluminum. Then poke through the hole with the awl, for a starter hole, and attach tail to arm with #4 screws. At the upper end, hold the rear arm firmly against neck and front arms, and with a 1/8" bit drill through the guide hole and into the neck about 1/2". Remove the rear arm, and enlarge the hole in the arm to 5/32", the hole in the neck to 9/64". Attach arm to neck with a 1" #8 screw. Replace neck on tub.

XII-E Add Felt Pads for Arm-tips

Now that the rear arm has been set, you will know just where on the head the tips of the arms will rest. The rear arm, of course, will be at the Very Back, up against the flange. The two front arms will contact the head in or near the First Full Valley, somewhere past the middle of the instrument. Mark these points of contact on the head, and rotate the neck out of the way. At each mark, stick a felt disk on the head so the entire end of the arm can rest on it.

XIII. Tune It Up and Plunk It

XIV-A Tune It

After placing the tub on the foundation and firmly tightening all the J-bolts, loosen the wingnut on the tuning bolt somewhat and turn the bolt to tighten string. I prefer to set the open note to the lowest E on a piano (one octave below the lowest note on a guitar) but you can crank it up to as high as the G above that E if you like. Tighten the wingnut on the

tuning bolt, thus pulling the hilt nut snug against the neck. This keeps the bolt from turning back, and holds the string in pitch.

Align the lower edge of the hose clamp with the lower edge of the nut. Tighten the clamp enough to hold to string firmly against the nut, but not brutally tight: the string needs to slip under it when you are tuning.

XIV-B Note These Tips

The way to get the best sound is to press the string in toward the neck at a point an inch or so above where the front arms join the neck, and let it snap off the end of your finger. Change pitch by pressing the string against the neck at different positions.

You can clean the industrial grunge off the string with isopropyl alcohol on a cloth. An occasional spritzing with Finger-Ease (available from a guitar shop) on the string and entire neck will help your hand move quickly between high and low notes.

If you put a mark at the octave point, you can finger there to tune directly to a guitar's low E. That pitch is easier to hear accurately than the bottom E.

Appendix One: Miscellaneous Final Touches

Trim Excess Off Front and Rear Ends of Y-struts

The Y-struts have been specified over-long, to accommodate differences between the Tub-O-Tone Two and Three models, and between one strut unit and the next. Extra strut length projecting past the edges of the arms can be trimmed off if and when you choose. A couple of possible trim patterns are suggested on § Patterns Page 2 (Fig. 2d.) The best way to do this is to sketch a profile on the strut while it's in place, then remove the neck, remove the strut, tidy up the profile lines and cut.

Paint or Polish the Tub

With a galvanized sheet tub, you get the most dazzle per dollar by just steel-wooling the thing. Use a medium grade of wool, and rub around the tub rather than with a circular or scrubbing motion. You can then wax it, or clear-coat it, or not. (If you use wax, put your Tub-O-Tone label on first and wax around it– otherwise you'll never get it to stick.)

Or you can paint it. No primer is necessary, but you do need to get the oxides and industrial grunge off to give your paint a chance to stick. I use mag-wheel cleaner, but another mild acid-based cleaner would probably do. Vinegar might even work. Whatever you use, be sure to rinse it well, and let the water drain out of the curl of the lip.

They make special primer for galvanized surfaces. It may add a little durability, but not enough to make it worth the trouble and expense, in my experience. The best resistance to scratches seems to come from what you put on top of the color coat, not under it. Wax itself will help. A clear-coat gives more protection. But if you use a metallic paint, you can't clearcoat it– at least, not with off-the-shelf clearcoat in spray cans. The surface will lose its metallic sparkle instantly.

Apply the Label

Trim the Tub-O-Tone label neatly about 3/16” outside of the outer maroon perimeter. The extra margin serves to protect the edge of the label from exposure to moisture.

Determine where on the tub you want the label to be. Make sure the surface is free of dust, wax, oil or moisture. Visualize, maybe even mark, the intended top-to-bottom line of the label on the target surface. Remove the paper backing from the label.

For the best chance of getting it aligned correctly, bow the ends of the label toward you so that a bend runs across the label top to bottom. Align this bend to your target line on the tub surface, and lightly stick the bend to the line. Don’t let go of the label, but check the vertical orientation and adjust it if necessary. When the vertical is correctly aligned, smooth the rest of the label onto the tub with gentle pressure working from the center toward the ends. Use your fingernail to make sure the clear cover bends down and contacts the tub soon after crossing the outer perimeter of the label (there’ll always be a bit of a gap, no matter what.).

NOTE: If the label is reluctant to separate from its backing, stick a short (1.5") piece of tape to the clear sheet, half on and half off the sheet pointing out from one end. Then attach a second piece of tape to the backing, at right angles to the first and as close to the edge as you can get it without the two tapes touching each other. Now you have handles with which to pull the two sheets away from each other.

Add Finial and Close String-Hole

When you’ve got everything put together and adjusted, and you’re sure it’s like it’s supposed to be (maybe after you’ve played it a bit), then crimp the little string finial cap [24] onto the end of the string. This will make your apologies more likely to be accepted when you accidentally poke somebody in the eye with the thing.

Another thing you can do after you’ve got the instrument all set up and adjusted, and played on it for awhile, is to take a screwdriver and a light hammer and tap the flared edges of the string hole snugly up against the string. This makes for cleaner-sounding low notes, in particular.

Add Note-Position Markers

There's no substitute for your ear, in hitting a note right on pitch, but it helps to put marks on the neck, to guide your finger to the right general neighborhood. Small flores-cent paper dots, available in strips at an office supply store, make good note markers. Stick them to the side of the neck, where they'll pass under the outer joint of your thumb.

Assuming your open note is an E, a good place to put them is at the octave E, plus the G#, A, and B positions on the way up to the octave, and into the second octave too. Have someone help you who has a good ear and a well-tuned instrument-- you plunk, they compare your note to theirs (give or take an octave.) (The intervals thus marked will remain valid even if you tune the open string to a different pitch.)

But you can't add many more stickers without encountering the Rumpelstiltskin effect-- if every tree has a yellow ribbon around it, you're as lost as you were when none did. Use the following technique to avoid the confusion of having too many fret markers:

Put a piece of colored tape (I use pin-stripe tape) along the entire length of the neck. Slice the tape at F (a whole tone above the open E) and peel off the piece above that. Slice at G and A, and remove the section between. Slice at B and C#, remove that section, and at Eb and F, removing that. Now you have: open E. Tape spanning F, F# and G. Space at G#. Tape spanning A, Bb, and B. Space at C. Tape spanning C#, D and Eb. Space for E. Then repeat for the second octave.

These tape sections will lead you to the right neighborhood for all your notes. For example, G# is in the 1st gap. A's at the beginning of the next tape, B's at the end, and Bb's somewhere in the middle, rather closer to the B end than to the A end, etc.

Appendix Two: Troubleshooting

1. **Small but obnoxious buzzes at fairly specific frequencies:** Make sure everything is snug. Check all wingnuts, screws and rivets. Crimp lip tighter around its ring. Make sure arms are snug against neck and Y-struts, and back ring pieces pressed firmly together.

2. **String slaps neck too much:** Some of this is unavoidable, and usually you'll be the only one who can hear it. But if it's annoying, give the neck more of a forward tilt by mounting the tailpieces higher on the rear arm. A thicker nut may help. Or tune to a higher pitch (no higher than G, though) to increase string tension. Or add a sidewise direction to your plunking style.

3. **Loud tinny tones at fairly specific frequencies:** Recondition the head. Regroove the first bend and go around the outer band again with the tub tool, really bearing down. Check to see that the Last Bend (around the perimeter of the inner disk) is intact, and emphasize it with the point of the dowel if not.

4. **Medium tinny tones at very specific frequencies:** Clamp or capo the string at the offensive pitch and let your fingers play lightly over the head as you plunk and listen. You can often feel specific points on the head that are especially active at these pitches– and the tinny tone will disappear when you press the points more firmly. Stick a patch of shelf liner to the underside of the head at these points, and the tinniness may be eliminated.

5. **Serious flapping from the lower realms, when you're playing loud:** Check tension of wire on center panel pressure strip. Possibly increase the tension. Or, add another semi-circle of carpet pad (or shelf liner) to the inside of the back panel (see § IV-C.)

6. **Tub too dad-blame loud:** Since you're standing inside the wave-length of the Tub-O-Tone's lower notes, volume may not be as apparent to you as it is to someone ten or twelve feet away. Your first clue may be a ringing in the ears, or plaster falling off the ceiling when you're jamming down at the Community Center. Stuffing a sock in each of the rear two soundholes will lessen the volume– or add another semi-circle of carpet pad as described in § IV-C.