

The Serpent Website's Sqworm

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Disclaimer

Neither The Serpent Website or the author make any guarantees that the following instructions are free of errors, or that a resulting instrument (the "Sqworm"), will play at any anticipated level the builder might desire or expect. These instructions are intended to be used in conjunction with certain basic construction information as described in The Serpent Website's 'Squarpent' construction webpage and article, in order to duplicate the author's prototype. The resulting instrument is intended to be an educational device, and no promise is made regarding its suitability for performance situations.

The Serpent Website's 'Squarpent' article and photos may be used to better understand how the basic wooden pieces must be laid out, cut and trimmed for the 'rabbet' joints, as well as how to fabricate and use jigs that could be required to assemble the basic pieces into the square tube that is the basis of the Sqworm; however, this Sqworm article provides an overview of these steps. Refer to www.serpentwebsite.com



the author playing the Sqworm prototype

What's a Sqworm?

A Worm is a soprano sized version of the bass Serpent, a Squarpent is a plywood, square bored 'straight' Serpent, so a Sqworm is a plywood, square bored 'straight' Worm. Worms and Sqworms are novelty (or, Joke) instruments, but they do play. Sqworm is pronounced 'squirm'. The Sqworm has a gentle, breathy sound like a 'mute cornetto', and uses typical Serpent fingerings and playing techniques.

Materials

- scraps of 1/4" plywood (actually 0.2" [0.5 cm]), with two finished/good sides, preferably exterior grade, preferably hardwood type (Oak, etc.)
- wood glue, exterior (water resistant) type, preferably gel formulation to resist running, e.g. Elmer's "Pro Bond Weather Resistant Wood Glue for Exterior Use"
- 5 minute epoxy (2-part)
- trumpet / cornet mouthpiece; to match 'authentic' Worm mouthpiece as closely as possible, cup (inner) diameter should be approximately 5/8" [1.6 cm], depth of cup from rim to throat should be approximately 3/8" [1 cm], and throat diameter should be 0.14" [3.5 mm]
- steel wire, for twisting twight to hold objects together during gluing (approx. 19 gauge [0.7 mm])
- cotton swabs ("Q-Tips" or similar)
- polyurethane varnish

Tools

- electric hand drill or drill press, with two bits: 0.14" (9/64") [3.5 mm] and 0.28" (9/32") [7 mm] diameters
- wood saw, circular or table type preferable, 'saber' or 'jig' saws or handsaws will also work
- X-Acto knife or similar razor edge modeling or woodworking blade
- pencil with suitable lead for marking wood
- sand paper
- ruler or drafting scale
- tape measure
- router with straight bit, for making rabbet cuts (optional; other methods may also be used to make these cuts)
- wide pliers (for twisting wire tightly)
- wire cutters
- hacksaw with metal cutting blade
- vise (optional)
- small rotary tool (Dremel or similar), with small wood cutting bit (for undercutting finger holes (small 'rat-tail' file may also be used)
- Set of clamps (optional; tape or wire will also work)

Sqworm Construction

THE SQWORM

CRITICAL DIMENSIONS:

BORE LENGTH = 21.75" (21 3/4") [55.24 cm]

BORE AT MOUTHPIECE = 0.14" [3.5 mm]

BORE AT BELL = 0.875" (7/8") [2.2 cm]

NOMINAL PLYWOOD THICKNESS = 0.2" [5 mm]

∴ DIMENSION 'A' = 0.2" [5 mm]

∴ DIMENSION 'B' = 0.1" [2.5 mm]

BORE SECTIONAL AREA AT BELL = 0.78 sq. inches [2 cm sq.]

HOLE LOCATIONS:

(MEASURED ALONG BORE CENTERLINE
STARTING AT END OF WOODEN TUBE
BY SMALL/MOUTHPIECE END)

HOLE #1 8.625" (8 5/8") [21.6 cm]

HOLE #2 9.25" (9 1/4") [23.5 cm]

HOLE #3 9.875" (9 7/8") [25.1 cm]

HOLE #4 13.125" (13 1/8") [33.3 cm]

HOLE #5 13.75" (13 3/4") [35.0 cm]

HOLE #6 14.375" (14 3/8") [36.5 cm]

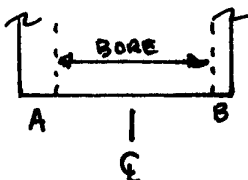
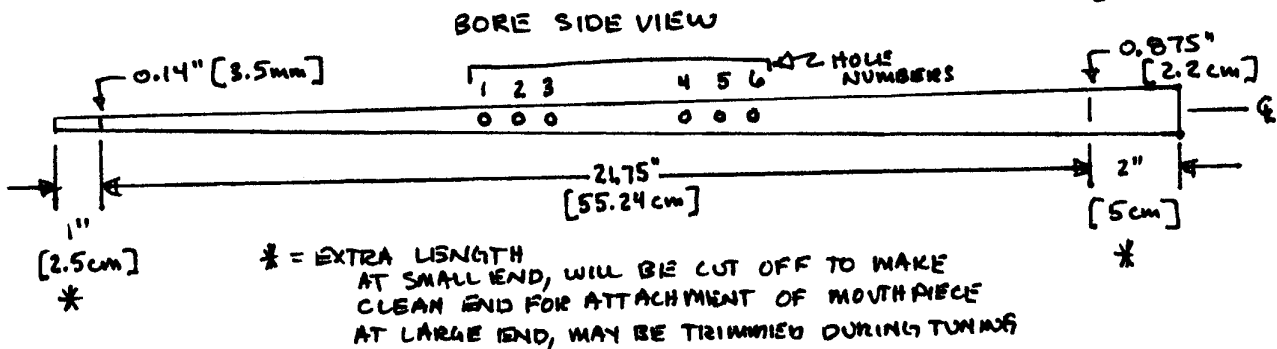
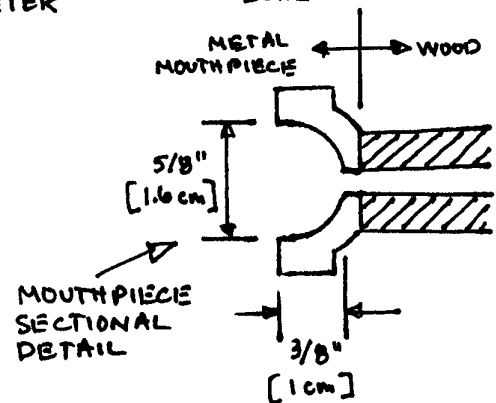
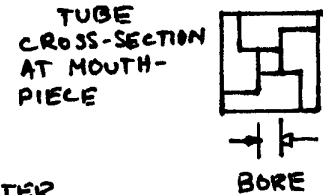
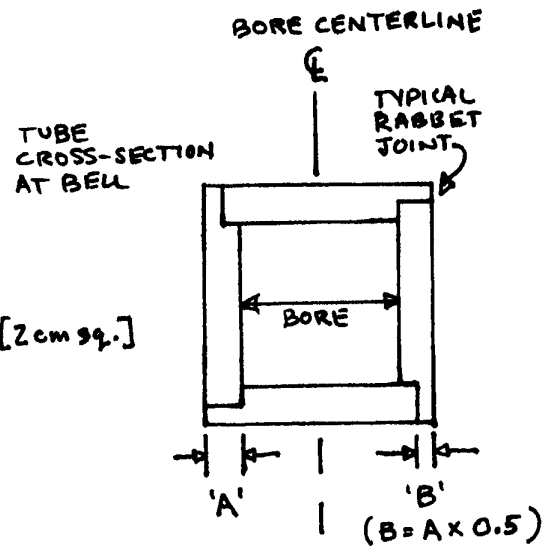
ALL HOLES ARE 0.28" (9/32") [7 mm] DIAMETER

MOUTHPIECE DIMENSIONS (APPROXIMATE):

CUP DIAMETER = 0.625" (5/8") [1.6 cm]

CUP DEPTH = 0.375" (3/8") [1 cm]

THROAT DIAMETER = 0.14" (9/64") [3.5 mm]



EXAMPLES OF TRAPEZOID LAYOUT
MEASUREMENTS AT LARGE-BELL (LEFT)
END AND SMALL-MOUTHPIECE (RIGHT)
END, NOT COUNTING 1" + 2" EXTENSIONS

Sqworm Construction

Initial Cuts

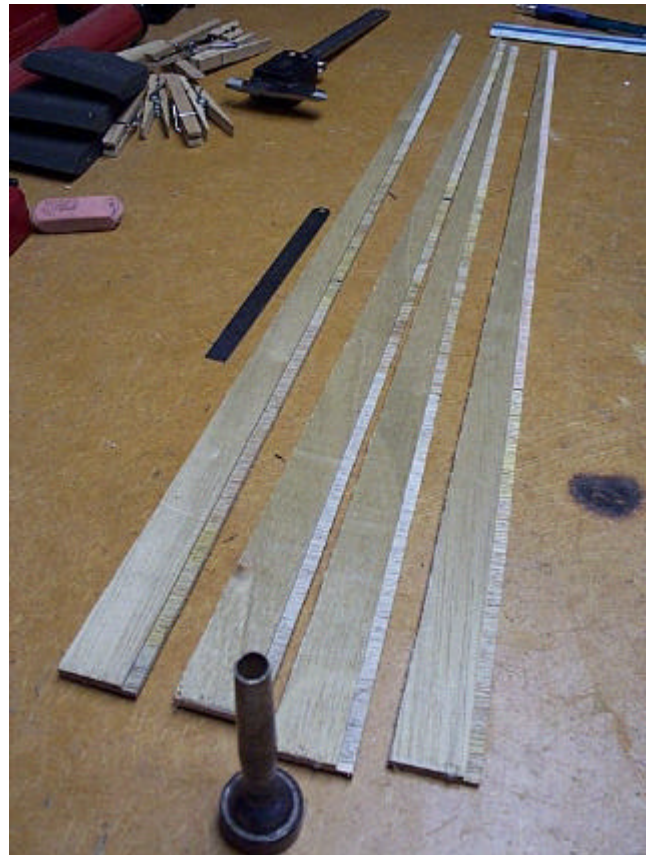
The bore of the Sqworm is made from a single tapered wooden tube with a square cross-section. *Refer to the diagram on page 2.* The tube is made from four identical pieces of plywood, cut in a tapered shapes and called *trapezoids*. After cutting the trapezoids from the plywood sheet, they need to be cut for making 'rabbet' type joints where they come together.

- Determine the actual thickness of the plywood; this will be dimension 'A'. Dimension 'B' will be half of 'A'.
- Decide which surface of the plywood has the better finish, and place it facing up on the table. Mark lines on the better side of the plywood; there will be four lines of about 25" [63.5 cm] length, drawn parallel to each other, and separated by about 1-3/8" (1.375") [3.5 cm]. The lines will be the *centerlines* of the bore (indicated by the combined C & L symbol in the diagram on page 2), and will be used for several critical measurements and cuts during construction. Make sure that the lines are far enough apart to allow for the tapering width of the sections (see above). Make sure that the centerlines are accurate, straight and clearly visible.
- At a point 1" [2.5 cm] from one end of the lines, make small marks 0.07" (approx. 1/16") [0.5 mm] to either side of the centerline. At a point 2" [5 cm] from the other end of the lines, make similar marks 0.4375" (7/16") [11 mm] to either side of the centerline. Take a straight edge (carpenter's or drafting type) and using the straight edge, draw lines between the small marks, continuing past the marks for the full width, to define the trapezoid shapes for all four sides of the tube. The diagonal lines define the edges of the *inside* of the bore.
- To define the actual cut lines for the trapezoids, draw additional lines parallel to the first diagonal lines and outside the 'bore' lines. On one side of each trapezoid, draw the line 'A' (remember dimension 'A' from above?) distance outside the bore line; this will be for the rabbet cut. On the other side of each trapezoid, draw the line 'B' distance outside the bore line; this will be the 'no varnish' zone that will be glued into the adjacent trapezoid's rabbet cut. Refer to the drawing on page 2 to see how the rabbet joints and cuts work out.
- Cut the 4 trapezoids from the plywood, being careful to make the cuts clean and accurate. Do not allow the saw to wander; the cuts must be straight.
- Varnish the unmarked side of the trapezoids. Avoid varnishing the 'no varnish' (B edge) zones; you will be varnishing the unmarked side, so the work does not need to be precise; it is better to get some varnish in the 'no varnish' zone than to leave part of the wood unprotected.

- Cut the rabbets along the 'A' edge of the trapezoids, making sure to cut on the varnished side of the wood. The cuts will be 'A' wide and 'B' deep. A router works best for this process, but successive adjacent shallow cuts with a table or circular saw work well, and other methods (including razor knife cuts) may also be used. Be careful when cutting near the small ends, as the wood is flexible there and could bend away from the cutting bit.

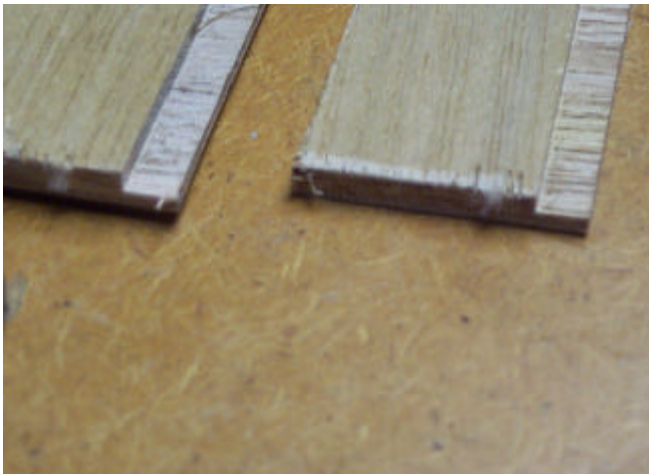


the four trapezoids after cutting them out from the plywood sheet



the four trapezoids after rabbet cuts have been made, see trumpet mouthpiece for scale

Sqworm Construction



closeup of rabbet cuts in trapezoids

Forming the Tube

With the Sqworm, assembling the tube is much simpler than with the larger square instruments like the Squarpent or Box-O-Cleide. The trapezoids are much stiffer relative to their length because the ratio of their size to their thickness is more advantageous. Accordingly, there is no need to make or use jigs or blocks.

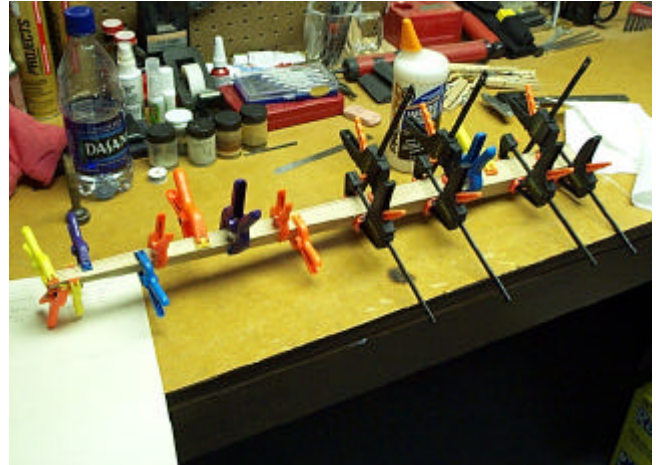
Test fit the four trapezoids to make sure that they will match up correctly at the rabbet joints (see drawings on page 2). Lay all four on a table, parallel to each other and pointing in the same direction. Place a small bead of wood glue in the rabbet groove of each trapezoid, trying to make the bead about half as wide as dimension 'A' of the cut, and position it close to the edge of the cut where the wood resumes full width. The objective is to have the right amount of glue, and have it located so that when the two pieces of wood are joined at the rabbet, the glue will have an equal area to squeeze into in either direction (without being forced from the joint into the bore or out of the tube).

Treating the trapezoid second closest to you as the base, rotate the adjacent trapezoids to vertical and joint them at the rabbets; they do not need to (and will not) fit perfectly at this stage. Before they can fall over, lift the fourth trapezoid, flip it over glue side down, and lay it in the top edges of the vertical trapezoids, forming a rough tube.

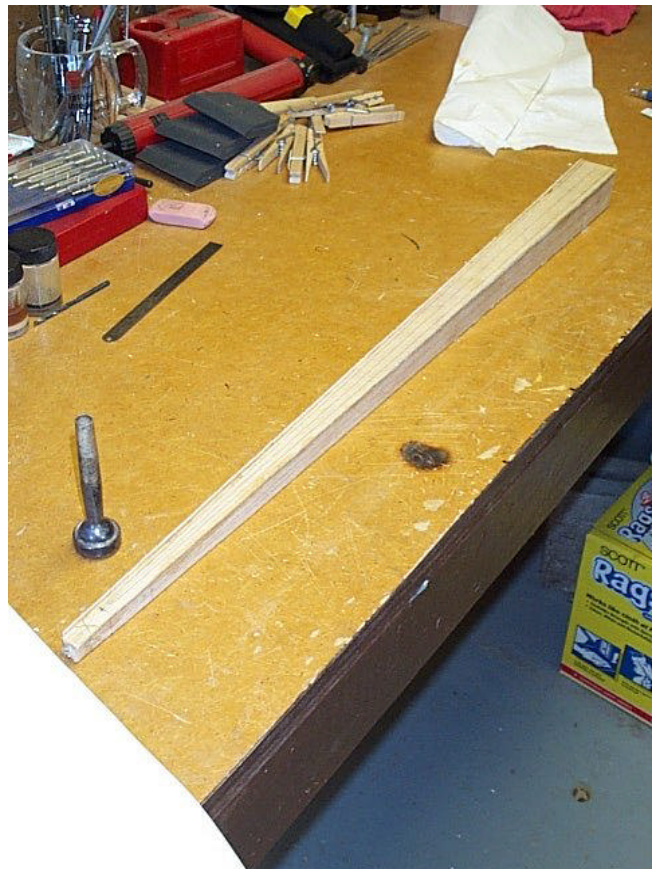
Use pieces of masking, drafting or office (e.g. Scotch) tape around the tube at each end, temporarily secure the pieces so that you can let go of them for a few moments without having them fall apart. It might be useful to place the handle of a screwdriver or similar tool inside the large end of the tube to keep the trapezoids from falling inwards.

Using clamps or tape or wire, start at one end of the tube and correct the alignment of the trapezoids. First make sure that they align lengthwise at the end, then make sure that the rabbets are fitting correctly, then secure this part of the

tube with the clamps, tape or wire. Move along the tube to the middle, doing likewise, then finally secure the other end. Quickly wipe any excess glue that is coming out of the rabbet joints. Continue to secure the tube, now at points in between the first three points, until the tube is firmly clamped or otherwise secured about every inch and a half [3.5 cm]. Wipe excess glue from the outside of the tube, then wipe excess from the inside at the large end, using a cotton swab. The bore at the small end will be too small to clear of excess glue, but this area will be trimmed and drilled out later. Allow the glue to set for several hours (e.g. overnight).



tube gluing with clamps (above), glued tube after clamp removal (below)



Sqworm Construction

Mouthpiece

The method used to fit the mouthpiece of the Sqworm is quite different from that on the other square instruments. The primary difference is that the mouthpiece is an integral part of the instrument and cannot be removed. The other difference is that the brass mouthpiece must be modified from its original form before it can be used on the Sqworm.

Inspect the mouthpiece that you have decided to sacrifice for this purpose, comparing it to the drawing on page 2. With the mouthpiece in its current form, the cup closes down to a small hole at the throat, then quickly tapers up to a much larger bore diameter within a couple of inches as part of the backbore within the shank. Serpent related instruments, such as the Sqworm, do not have this backbore; instead the bore increases linearly from the mouthpiece throat all the way to the 'bell' opening. Accordingly, it will be necessary to remove the part of the brass mouthpiece that is associated with the backbore.

Insert a small object, such as a screwdriver blade or drill bit into the mouthpiece cup until it stops at the throat. Make sure that the object is narrow enough that it does not stop short of the throat due to contact with the bowl of the cup, and is also wide enough that it does not go past the bottom of the cup and into the throat. Looking at the mouthpiece sideways, grip the object just where it lines up with the rim of the mouthpiece, and remove the object while still keeping the fingers at this critical location. Reposition the object to the outside of the mouthpiece, line up your fingers with the rim, and mark the outside of the mouthpiece where the other end of the object is. This mark shows where the cup ends and the throat begins. Repeat this measurement once or twice to make sure that there is no error. Make another mark about 0.09" (3/32") [2 mm] past the first mark, away from the rim; this will be the cut point.



mouthpiece marked for cutting (see black mark near points of caliper)

Make a mark on the wooden tube 1" [2.5 cm] from the small end. Using a saw with fine teeth suitable for cutting across the wood grain, cut off the end of the tube at this point, being careful to make the cut square and straight. Test fit the mouthpiece to the wood, checking that the diameter of the metal roughly matches the outer width of the tube where they meet. Remove any burrs from the wood and metal where they have been cut, but do not file or sand them smooth; the rough texture here will help the glue to hold them together. Use a #29 drill bit [3.5 mm dia.] to remove any dried glue from the bore at the small end of the tube, blowing out the debris.



small end of tube trimmed at 1" mark

Mix some epoxy, and pack a small amount into the bore at the small end of the tube; it should fill the bore for between 1/4" and 3/8" [6 mm and 9 mm]. Wipe excess epoxy from end of tube, and allow epoxy to fully cure. File or sand away any dried epoxy that might prevent the mouthpiece from fitting square against the wood. Using a #29 drill bit (or a drill bit that fits the mouthpiece throat, about 0.14" [3.5 mm] diameter), drill a slight indentation into the dried epoxy where it fills the end of the wood bore; do not drill all the way through the epoxy.

Orient the tube vertically, with the small end pointing up, and secure it so that it stays straight up and cannot fall over. Mix more epoxy and spread a thin layer on the entire cut

Sqworm Construction



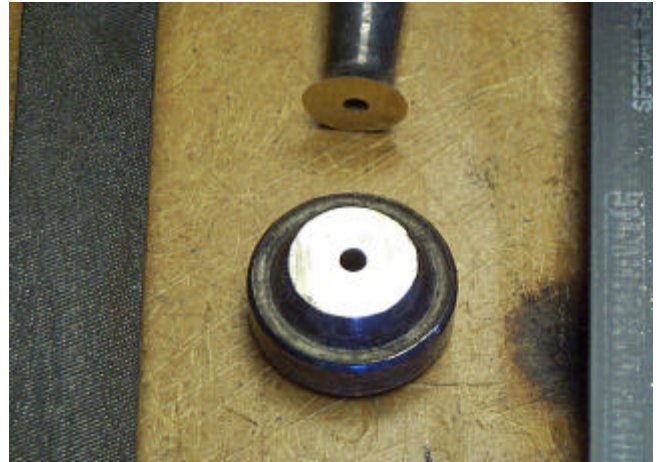
drilling out excess glue at small end of bore



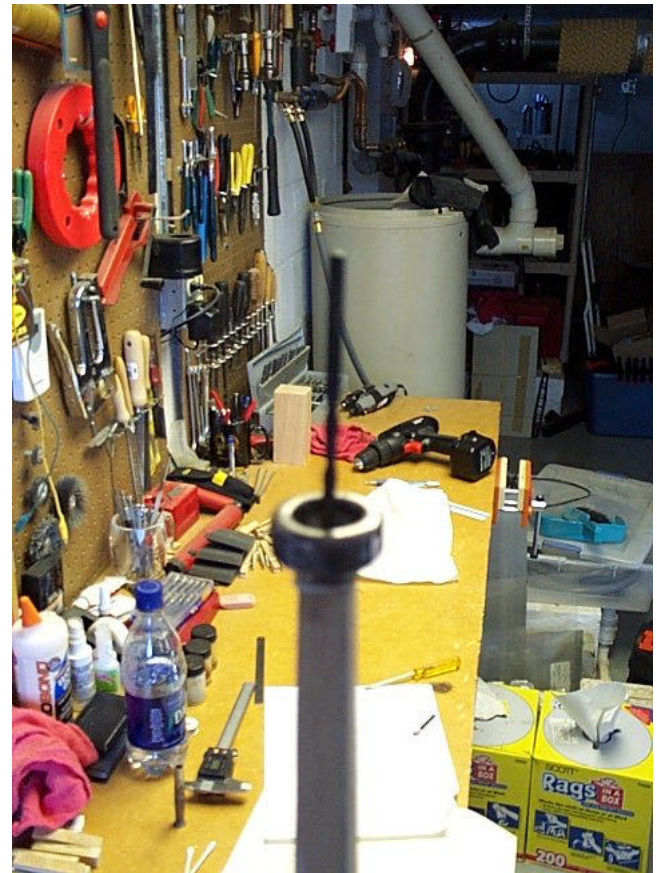
filling small end of bore with epoxy

metal surface of the mouthpiece. Apply a thin layer of epoxy to the entire end surface at the small end of the tube. Place the point of the drill through the mouthpiece throat so that it just extends past the glue, then place the mouthpiece on the tube, using the drill point to center it with the previously drilled indentation. With the drill still centering it to the tube, twist the mouthpiece a bit back and forth to displace any excess glue and use cotton swabs to wipe the glue from where it squeezes out. Carefully remove the drill from the mouthpiece and wipe off any epoxy. Look inside the mouthpiece, and wipe away any epoxy that might have

gotten into the cup (epoxy inside the throat is OK), being careful to avoid moving the mouthpiece. Allow epoxy to fully cure.



mouthpiece after cutting to remove the shank



mouthpiece aligned to bore by using drill bit

Using the same drill bit, drill out the mouthpiece throat and the epoxy plug that was previously made inside the small end of the wooden tube. Since all drilling is through the plastic (epoxy) resin, the result should be a very smooth opening that can be visually inspected by looking at a bright light through the mouthpiece. If there are any burrs or obstructions, run the drill back into the hole until it is clear. Blow strongly into the mouthpiece to clear the bore of debris.

Sqworm Construction



mouthpiece glued to wooden tube



*drilling out mouthpiece throat to
remove excess epoxy*

Tuning

The Sqworm is now ready for its first test blow. Blow a few 'bugle' calls, such as "Taps", to verify that the bore integrity is adequate. The tone produced should be a soft, muted and breathy sound. If the instrument does not seem playable at this point, check for obstructions or debris in the bore, and try rubbing wood glue into all the rabbit joints

from the outside, then let the glue dry and sand it off (this should close any leaks).

Using a musical instrument tuner or similar device, play a 'C' on the instrument. It will be quite flat, probably sounding as low as an A. Use a fine toothed hand saw (the same one used for trimming the small end of the tube), and remove about 1/2" [1.3 cm] from the large, or 'bell' end of the tube, and try the test note again. Keep in mind that the Sqworm, like any serpent related instrument, will have very flexible pitch. It is advisable to actually play a bugle call or any series of partials in order to find the true pitch center for the bore before comparing the C pitch to the tuner. If the note is still flat, remove more of the tube and repeat. As the pitch gets close to being in tune with the tuner (calibrated to A=440 Hz), trim smaller amounts. The final trim point should be approximately 2" [5 cm] from the original end of the tube. On the prototype, the tube was tuned at about 2.5" [6 cm], but later seemed a bit too sharp....be careful!



tuning the tube by trimming large end

Finger Holes

The Sqworm, like other instruments in the serpent family, has only six finger holes, and they are spaced in two groups of three, placed where the fingers can easily reach them and not where they make the best acoustical sense. Fortunately, the taped bore gives such great pitch flexibility that the player's embouchure can bend the misplaced notes into tune.

Using a ruler or tape measure, start with it's end at the approximate location of the throat of the mouthpiece (visualize where it is, it will be quite close to the end of the wooden tube), and lay the measuring edge along the tube's marked centerline. Make cross marks on the centerline at the six positions indicated in the drawing on page 2 (8.625", 9.25", etc.)

Using the same drill bit as with the mouthpiece throat, drill through the plywood at the six marked positions, being

Sqworm Construction

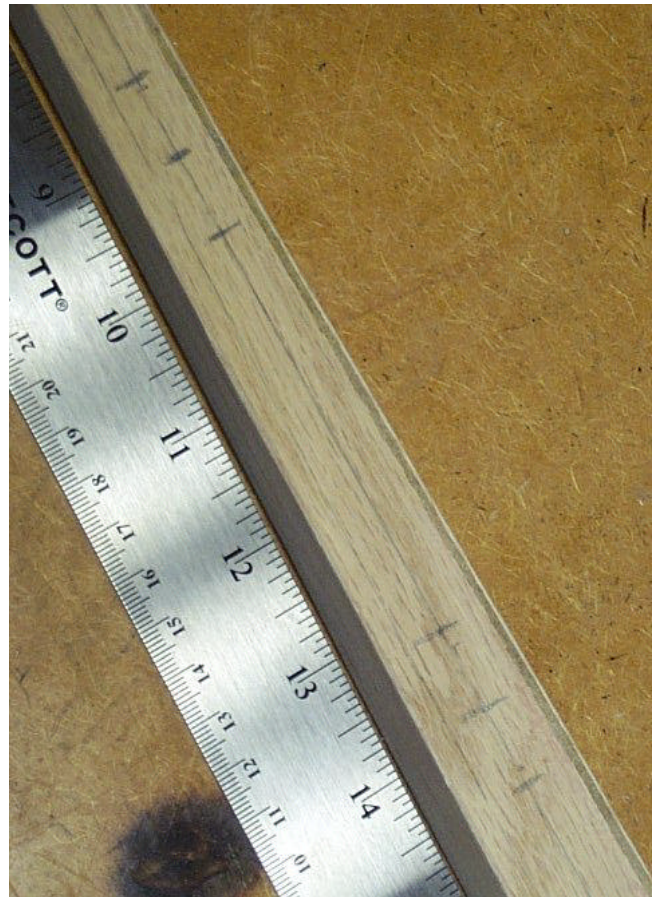
careful to use high drill speed and very slow drill feed/advance. If a drill press is available, it is better to use it than a hand operated electric drill, because the bit cannot suddenly jump through the wood when the point starts to break through, and the hole will be cleaner with less damage to the wood inside the bore. Replace the drill bit with the larger 0.28" (9/32") [7 mm] diameter bit, and enlarge the six holes. During this process, use the drill's highest available speed and be extra careful to avoid making a rough hole.



finger hole positions have been marked

With the six holes drilled and enlarged, use a wood cutting rotary bit (see photo on page 9) or a "rat-tail" file to diagonally undercut the holes. Each hole should be left at the drilled diameter from the outer surface of the wood to about half way through to the inner bore, then undercut to a larger diameter at about a 45 degree angle the rest of the way in. Undercutting makes the holes seem larger to the vibrating air column inside the tube, and this increases their effectiveness. Undercutting also helps remove the inevitable burrs and splinters created during drilling.

Sand the outside of the tube, removing excess epoxy near the mouthpiece, any pencil lines that were drawn on the wood, and any remaining burrs around the outside of the finger holes. Also file and/or sand the edges of the wood at the 'bell' opening.



closeup of finger hole position marks

Dust or wipe the wood to remove any dust, and apply a coat of varnish. Use a cotton swab to apply varnish to the inside and undercut areas of the finger holes, and also make sure to varnish the edges of the wood at the 'bell.'

When the varnish is dry, use a very fine sandpaper moistened with water, and lightly sand over the outer surface of the instrument (this step is optional). Dry and wipe down the instrument; if the finish is too dull after sanding, apply another light coat of varnish. Make sure to



finger holes have been drilled

Sqworm Construction

check the finger holes and remove any cotton fibers that may have come off during varnishing.

The Sqworm is now complete.



closeup of rotary bit used to undercut finger holes

Playing the Sqworm

The Sqworm plays much like any other serpent related instrument. As such, it requires that the player have a strong and determined embouchure, and also a good sense of pitch. To be successful, the player should read the music as would a singer, hearing the proper pitch in his/her mind before trying to produce it. Then, use the “think system” to will the instrument to produce that pitch. With practice and experience, the determined player should be able to use the Sqworm over a practical musical range of perhaps 2 octaves, maybe a bit more.

The fundamental pitch of the Sqworm is middle ‘C’. The player may experiment to find workable fingerings for each note, or may start with any published serpent fingering chart (such the chart listed in the Serpent Website, www.serpentwebsite.com). Any published chart is simply a beginning, as every instrument will be somewhat different, and any given instrument will have varying fingerings depending on many other conditions. For example, the ‘G’ an octave and a half above middle ‘C’ on the prototype Sqworm varies considerably from day to day, and requires different fingerings and lots of lip bend to play in tune. This is typical behavior for serpent type instruments.

The Sqworm is not likely to be very useful for playing in loud situations, as it works much better at quiet playing levels. The player should strive to obtain a consistent, smooth and gentle timbre on all notes. Learn to internalize the idiosyncrasies of the instrument, automatically adjusting fingerings and lip tension so that each note comes out at the correct pitch, in tune, and with the desired tone quality.



Comparison of instrument size and finger hole locations between instruments of similar overall size:

Top - alto recorder in F

Middle - cornetto in G

Bottom - Sqworm in C

Sqworm Construction

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