

The *Serpent Website's* Squarpent

Construction Guide

Neither The Serpent Website or the author make any guarantees that the following instructions are free of errors, or that a resulting instrument (the 'Squarpent') will play at any anticipated level the builder might desire or expect. These instructions are intended to be used with the photos and related 'Detail' graphic files in order to replicate 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.

Materials

- 4' x 8' sheet of ¼" plywood (actually 0.2"), with two finished/good sides, preferably exterior grade, preferably hardwood type (Oak, etc.); the prototype wood cost only \$20 at a Menards store.
- scrap of ½" dia. wooden dowel
- scrap of ¾" dia. wooden dowel
- 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)
- mouthpiece; serpent mouthpiece preferable (see makers), but trombone/baritone/euphonium type will work
- steel wire, for twisting tight to hold objects together during gluing (approx. 19 gauge)
- masking tape or similar, to prevent varnishing certain parts of wood
- cotton swabs ("Q-Tips" or similar)

Tools

- drill, with assorted bits, plus ½" diameter bit suitable for wood boring
- wood saw, such as circular or table type ('saber' or 'jig' saw, hand saw, etc. will also work); *radial arm saw, band saw, 'saws-all' types are not suitable*
- X-acto knife or equal razor edge modeling or woodworking blade)
- pencil with suitable lead for marking wood
- sand paper
- metal straight edge to guide knife
- carpenter's 'square' or drafting triangle, to assist in marking accurate 45 and 90 degree angles
- ruler
- tape measure
- mitre saw or other wide-blade saw with fine teeth
- router with straight bit, for making rabbet cuts (optional)
- small round wood rasp/file, or preferably 'Dremel' type tool with small cutter bit (e.g. Dremel #115)
- wide pliers (for twisting wire tightly)
- wire cutters
- pipe clamp (optional)
- heavy twine or nylon cord (clothes line, etc), about 8' required

Initial Cuts

The bore of the Squarpent is made from four identical pieces of plywood, cut in a tapered shape and called *trapezoids*. After cutting from the plywood sheet, the four trapezoids need to be cut for making 'rabbet' type joints where they come together.

- Determine actual thickness of plywood; this will be 'A'. Dimension 'B' will be half of 'A'.
- Mark four lines along plywood, going the long (8' / 244 cm) direction. First line to be 2" (5.08 cm) from long edge of plywood sheet, and other lines to be every 4" (10.16 cm). These are the center lines of the bore, so make sure they are accurate and clearly visible.

- At one end of lines, make small marks 1.75" (4.44 cm) on either side of center line. At other end of lines, make small marks 0.25" (0.63 cm) on either side. On opposite (unused) long side of plywood, cut a strip about 3" (7.62 cm) wide, and use it's clean (factory cut) edge as a straight-edge. Or, if a carpenter's long straight edge is available, use it. In either case, draw diagonal lines between the small marks to define the trapezoid shapes. Along one edge of each trapezoid, make a parallel line that is 'A' distance beyond the original line; this will be the actual cut line for this side of the trapezoid. Along the other edge of each trapezoid, make a parallel line that is 'B' distance from the original; this will be the cut line for this side.

Refer to the Detail 1 graphic.

- Cut the four trapezoids from the plywood sheet, being careful to make the cuts clean and accurate. Do not allow the saw to wander; the cuts must be straight.

- On the large end of each trapezoid, cut 3" (7.62 cm) off to make the center line 93" (236.22 cm) long.

- Place masking tape along the inner sides of each trapezoid, along the 'B' line to the edge. Coat the inner sides of the trapezoids with polyurethane varnish; the tape will prevent varnish from getting on the area that will be glued later. Don't worry about the other edge with the 'A' line, since the rabbet cut will remove varnished wood there. One coat of varnish should be adequate, except for the first 12" (approx. 30 cm) from the small end; use a double coat here because it will see more moisture.

- Cut the rabbets on the 'A' side of each trapezoid, making sure to cut on the varnished side of the wood. The rabbet cut will be the full width 'A', and will be 'B' deep (i.e. half the thickness of the wood). *Refer to the Detail 1 graphic.* A router is best for this, with the router guide set to follow the edge of the wood and the bit set for a depth of 'B'. If a router is not available, careful repeated shallow cuts with a circular or table saw will achieve the same rabbet cut. If necessary, a hand planing tool or even the X-Acto knife can be used to make the rabbet cuts. *Save the sawdust from routing; if routing was not used, save sawdust from cutting the trapezoids.*

Jigs

The four trapezoids will be glued together into a tapered box, or 'tube'. The rabbet joints will help by keeping the edges locked together, and will help keep the glue in place for the best quality joint. However, it will still be difficult to align the eight edges of the four trapezoids before the glue runs or begins to set. Making a set of jigs will help.

- From the remaining plywood, cut nine squares, each 6" x 6" (15.24 sq cm); these will be for the outer jigs.

- For the outer jigs, mark a square on each one, with progressively larger sizes (see **Dimension** section), centered in the jigs. Drill a 3/8" (1 cm) hole at each corner of each marked square (this will help prevent excess glue at the outside of the rabbet joints from touching the jigs), and saw between the holes to remove the unwanted wood. Mark the jigs 1 through 9.

- From the remaining plywood, cut three squares each of 2" x 2", 3" x 3", 4" x 4" (5.1, 7.62, 10.16 sq cm, respectively). Glue the same sized square together to make thicker pieces, then trim them to be 1.5" x 1.5", 2.5" x 2.5", 3.25" x 3.25" (3.81, 6.35, 8.25 sq cm); these will be for the inner jigs. Optionally, use same sized square pieces cut from 1/2" or 3/4" plywood scraps.

- For the inner jigs, cut/file/sand the corners off. This will help prevent excess glue at the inside of the rabbet joints from touching the jigs. Drill a small hole through the center of each inner jig, large enough pass the nylon cord through easily.

- Cut a length of 1/2" diameter dowel, about 2" long. This will be a fourth inner jig and will also be part of a form for the mouthpiece receiver assembly.

- Lay one of the trapezoids down, with the inner (varnished) side facing up (the rabbet cut will also face up). Place the three inner jigs at the point where they exactly touch the inner edge of the rabbet cut on one side, and the 'B' line on the other. Staple (or nail) them to the trapezoid. Pull the nylon cord through the holes in the jigs, making a large knot (so large that the knot cannot pull through the holes) on the side of each jig that faces the small end of the trapezoid. Leave a loop or few inches of slack cord between each jig. The free end of the cord should extend past the large end of the trapezoid.

- Mark the 1/2" dowel at a point 1/2" (1.27 cm) from one end; this will be the insertion mark during gluing.

- Test fit the trapezoids and outer jigs, to make sure everything fits. This will also be practice for the actual gluing.

- Lay the four trapezoids down, parallel to each other. Lay a bead of wood glue in the rabbet cuts of each trapezoid. With the inner-jig-equipped trapezoid as a base, temporarily locate the dowel at the small end (held loosely in place with tape if necessary), and position the other trapezoids loosely onto the inner jigs & dowel, and fit the outer jigs in place. Make sure all sides are even, the jigs fit firmly, the outer jigs set squarely on the floor or table, and all edges and rabbet cutouts fit correctly. Wrap lengths of wire around the setup and twist tight with the pliers. Recheck all alignments. Wipe off excess glue. Check the dowel; do not allow it to be glued to the trapezoids, as it must be removed in the next step.
- Allow the setup to dry overnight.
- Remove the dowel from the tube. Mix sawdust with epoxy to make a wood-filled paste. Coat the marked end of the dowel with lots of this paste, and stick it back into the small end of tube. The ½" mark should be flush with the end of the tube. Use a screwdriver or knife blade to pack more of the wood/epoxy mixture into the spaces around the dowel (at the corners of the tube), estimating the total amount needed to completely fill the voids for the entire ½" length.
- Remove the wire and outer jigs; it may be necessary to tap on the jigs with a mallet to loosen them.
- Remove the staples holding the inner jigs. Tug on the nylon cord to dislodge the largest jig; once it is free, use the same method to pull the others out of the tube. Smear some wood glue into the staple holes, work it in, and wipe off the excess.
- Cut off about 1/16" (0.16 cm) from the small end of the tube, removing the excess dowel in the process. Check that the epoxy has filled all space between the remaining dowel and the inside of the tube. If not, add more, work it in, and allow to set. Drill a small hole through the center of the dowel, then follow with a ½" bit to remove most or all of the dowel. The remaining wood-filled epoxy will make a good mouthpiece receiver. Check with a flashlight that excess epoxy has not obstructed the tube beyond this point. Small tools/bits may be used to remove any excess.

Testing

- Fit the mouthpiece into the receiver. Test the tube by playing a series of notes. Only a few pitches will be possible at this point, but it should be easy to play bugle calls (taps or reveille, as might be appropriate). The tone should be clear and firm, and the bugle call notes should be easy to sound. If not, check for tight mouthpiece fit, and make sure that there are no leaks in the glue joints of the tube. If in doubt, smear more wood glue on the joints, work it in, and wipe off the excess. Do not proceed with the next steps until the integrity of the bore has been proven by playing.

Shaping

- Measure and mark the cut lines for the mitre cuts that will allow reshaping the instrument (see **Dimension** section). Be careful to use a square aligned to the marked center line of the bore; do not align to the edge of the tube! Cut lines will be either 45 or 90 degrees relative to the center line. *Refer to the Detail 2 graphic.*
- Use a mitre saw or hand saw to make the mitre cuts. Do not use a mitre box unless experienced with its use for compound cuts. Best results will probably be achieved just carefully following the cut lines by hand and guided by eye.
- Take the two small 'bow' sections and fit them to the two larger sections that follow them. Note that precise alignment will not be possible. This is because the angled cuts on a tapered bore will result in different cross-sections across the cuts. When the 'bow' sections are rotated to make the corner, a larger cross-section of one tubing section will be placed against a slightly smaller cross-section of the other tubing section. The resulting irregularities are of minimal consequence. Apply wood glue to the edges of both sections at each corner, checking for optimal alignment by keeping the marked center lines lined up. Block the sections with heavy objects and allow the glue to dry.
- Add the remaining sections (except the bocal section) using the same technique. Before gluing, carefully cut small sections of ¾" (1.9 cm) dowel to use as spacers between parallel sections. There should be four spacers for the bell section and two spacers for the other section. These spacers will provide mechanical strength and take the strain away from the weaker glue joints at the mitre cuts. Use wood glue on the ends of the spacers; cotton swabs may be used to wipe away excess glue.
- Stand instrument vertically against a firm object. Glue the bocal section onto the rest of the instrument. Clamps, wires, tape, etc; may be used to hold this joint in place while the glue sets. Make a small piece of

wood from scraps to fit in the angle of the bocal, and glue it in place to reinforce the joint. A metal angle bracket may also be used for this purpose.

Finger Holes

- Fit the mouthpiece and play notes, repeating the earlier tests. Any leaks may be repaired by working more wood glue into the faulty joint(s).
- Play the lowest 'C' pitch, which will be two octaves below middle-C. Using a piano or other instrument, or an electronic musical instrument tuner, check to see how flat the sounded pitch is. Use a saw to carefully trim away from the large end of the tube, ½" (1.27 cm) at a time, until the C is fairly in tune. In theory, 96" (244 cm) would provide a C, but in practice the actual length will be between 91" and 93" (approx. 231 & 236 cm).
- Starting at the mouthpiece end, carefully measure along the marked center line. Make marks for the six finger holes (see **Dimension** section). Be careful to avoid losing or gaining distance at the bends in the tube. All bends are on the same plane, except for the bend nearest the mouthpiece; make sure to measure this bend correctly.
- Hold the instrument with finger tips on the finger hole marks. Find where the middle fingers most comfortably extend past the center line and re-mark the middle holes in each set to accommodate the off-center positions.
- Drill small pilot holes at each location, then carefully bore out with the ½" bit. Use the correct speed to minimize burring or otherwise damaging the wood fibers.
- Use a rotating cutting tool or round file to undercut all finger holes. Serpents suffer from having finger holes that are too small, since the finger tips must be able to cover them. Undercutting the holes compensates somewhat for this; amount of undercut is not too critical in this instrument. The holes may be made slightly larger than ½", as long as the fingers can easily cover them.
- Sand the outside surfaces, edges, glue joints, and finger hole edges.
- Shake and rotate the instrument to remove as much sawdust and wood shavings as possible.
- Apply a coat of polyurethane varnish to the outside of the instrument. Use cotton swabs to apply varnish to the inside edges and undercut surfaces of the finger holes.

Complete

- Fit the mouthpiece and experiment with fingerings, using the C serpent chart found on the Serpent Website as a starting point.
- As with any keyless serpent, there are good notes and bad notes on the Squarpent. Some notes must be lipped quite a bit up or down, and one or two will probably never quite be there. This is typical serpent behavior, and each player must come to grips with each individual instrument, finding a way to optimize the playing characteristics and resulting sounds.
- The trombone (modern) mouthpiece will make the sound bigger and brighter, but will actually make some of the bad notes even worse. Using a real serpent mouthpiece will result in a muddier, less distinct (i.e. traditional) sound, but will allow more flexibility when improving bad notes by lip technique. The ½" diameter receiver is typical of historical instruments, so most real serpent mouthpieces will fit.
- The inventive builder might attempt to figure out a way to make the bocal section removable. Doing so will make the instrument easier to store and transport.
- Don't stop with the Squarpent! If you find you like the challenge of playing an instrument with these characteristics, *move on to a real serpent*.

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Dimensions**General**

Length of bore : approx. 92" (234 cm)

Bore taper : 0.032

Minimum bore : 0.5" [0.25 in²] (1.27 cm [1.61 cm²])

Maximum bore : 3.5" [12.56 in²] (8.89 cm [81.03 cm²])

Typical serpent bore measured at bell end : 4" [12.56 in²] (10.16 cm [81.03 cm²])

Wood thickness : 0.25" nominal, 0.2" actual (0.5 cm)

Outer Jigs

All 9 jigs are 6" (15.25 cm) square

Cutouts:

1	1"	2.54 cm
2	1.35"	3.43 cm
3	1.7"	4.32 cm
4	2.05"	5.21 cm
5	2.4"	6.1 cm
6	2.75"	7 cm
7	3.1"	7.87 cm
8	3.45"	8.76 cm
9	3.8"	9.65 cm

Inner Jigs

All three jigs, not including fourth / dowel jig, are thicker wood pieces

1	0.5"	1.27 cm	small end	use ½" dowel
2	1.5"	3.81 cm		
3	2.5"	6.35 cm		
4	3.25"	8.25 cm	large end	

Mitre Cuts

Measure from mouthpiece end to where mitre cut will intersect the bore centerline

Cut A	10"	25.4 cm
Cut B	26.375"	67 cm
Cut C	28.375"	72.07 cm
Cut D	71"	180.34 cm
Cut E	74.625"	189.55 cm

Finger Holes

Measure from mouthpiece end along bore centerline; holes are all ½" diameter (1.27 cm)

1	44.625"	113.35 cm
2	46.3125"	117.63 cm
3	48"	121.92 cm
4	60.75"	154.3 cm
5	62.625"	159.07 cm
6	64.1875"	163.04 cm