Simple and Efficient Reed Pipe Construction in Wood

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Abstract: A novel organ reed pipe design is described. This design can be made almost entirely from wood (except for the reed tongue and tuning wire, and a few screws) and is easy to produce in a woodworking shop using only a bandsaw, drill press and assorted bits, and hand tools. A complete method to produce a reed pipe according to this design is presented, as well as a method for precisely making triangular pieces using a bandsaw for tapered wood pipes.

1. Introduction

In the early 2000's, I had the opportunity to enjoy the use of a small workshop space at no charge. At that time, due to limited budget I had only two major tools, a small bench bandsaw and a used drill press -- the drill press was given to me by a furniture maker friend. I also had the use of my family's hand drill and hand sander, a drill press vise, and a variety of small hand tools and drill bits, files, clamps, straight bars to use as band saw fences, measuring tools, etc.

During that time, I was tinkering extensively with organ pipe making, trying to replicate in my little shop all the major classical and theatre organ flue and reed pipe types in wood. The development of the reed pipe design illustrated and described in this paper was motivated by three factors: (1) a mathematician's natural wish for elegance and simplicity in construction, (2) the limitations of the tooling present in my workshop, and (3) the need to design around a patent (US 5233897) -- which in those days was still in effect and unexpired -- covering a simplified method for making reed pipes that would have been convenient to use with the tooling present in my workshop.

This design resembles that developed by Marc Elbasani [1] but seems more elegant and more material-efficient, and likely permits a wider range of resonator shapes.

2. Overview of the Design

Figure 1 shows a side elevation cross section of the notable parts of the reed pipe design. The pipe consists of essentially two parts: a typical reed pipe resonator and a boxlike structure analogous to the conventional reed pipe boot. Rather than a typical shallot, a 'virtual shallot' is formed by the lowermost part of the resonator and the slotted 'floor' of the boot box. Figure 1 indicates a resonator shape that would be good for a saxophone or harmonic saxophone type pipe. (Oboe and kinura type pipes would have a narrower tapered pyramidal shape, orchestral trumpet pipes would have a parallel segment, then a pyramidal segment, and then a flared end, clarinet and crumhorn pipes would be wider or narrower parallel-sided, etc.)

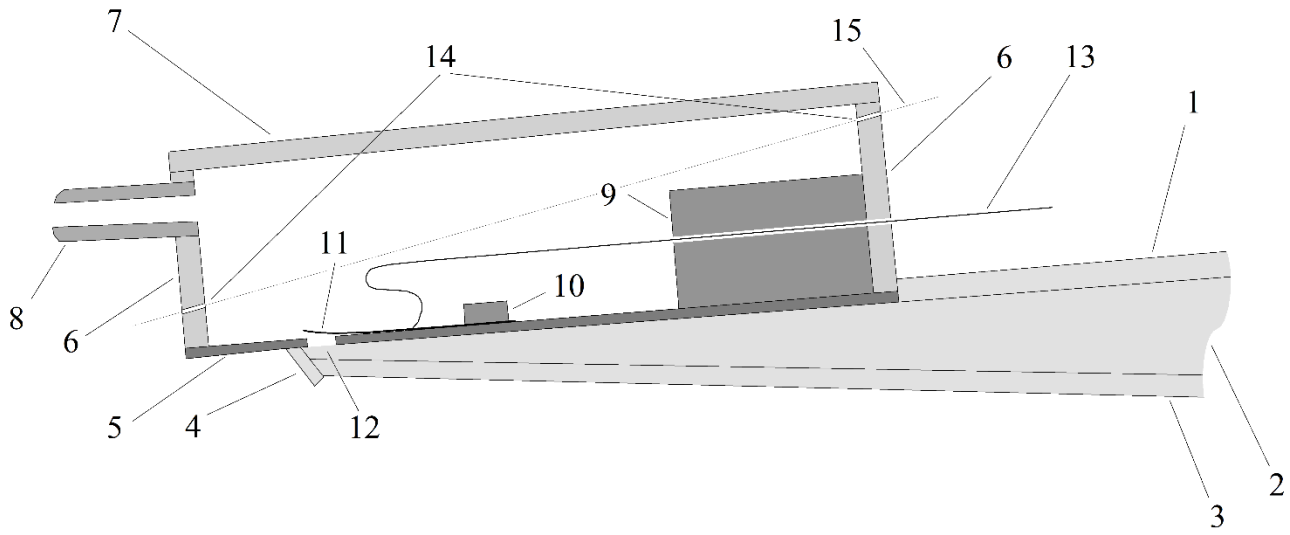

Figure 1

The main resonator can be a rectangular, pyramidal, flared or any other form constructed from sheets of thin wood. This resonator includes a bottom **3**, two sides **2**, and a top **1**. Notice that the top does not extend the whole length of the resonator due to the presence of the boot box. The boot box has a bottom **5**, four sides (two shown as items **6**) and a top **7**. To allow this design to simulate various shallot configurations (pocketed, strongly sloped, normal-ended) the end of the resonator can be trimmed after assembly and covered with an end-cap **4**.

The boot box is split into two parts at a plane **15** so it can occasionally be disassembled to maintain the tongue **11** and tuning wire **13**. The two parts of the boot box are normally secured by screws (not shown) and gasketed with a leather or foam rubber thin gasket **14** to make it more airtight. The boot box also includes the pipe toe **8**, positioned so that the air stream entering the pipe does not directly impact the reed tongue. It's important to note that the pipes' center of mass is not directly above the toe, so some stabilizing or bracing of the pipe is needed if it be mounted vertically, rather than *en chamade*. For pipes mounted *en chamade*, locating the pipe toe **8** in the top **7** of the boot box near block **9** may be preferable.

Analogously to the conventional design of reed pipes, a large solid block **9** is present and located on the inside of the boot box. The tuning wire **13** passes through this block to the outside of the pipe, allowing adjustment of the vibrating length of the tongue in the usual way without needing to disassemble the boot box. The hole through which this tuning wire passes should be very close-fitting to minimize air leakage, and may be coated inside with a bit of graphite powder to allow for easier sliding of the tuning wire. The hole is shown at exaggerated width in the drawing for clarity.

The upper end (toward the right, not shown) of the resonator may be fitted with the usual tuning slots, flaps, hoods, etc. as one would wish for reed pipe tuning. By adjusting the tuning wire and the tuning appendages on the resonator, the resonator and tongue frequencies can be matched to one another, and brought into resonance at the desired tuning frequency.

Somewhat differently to the conventional design of red pipes which use a wedge to hold the tongue in place, I decided to include a small block **10** of strong hard wood secured by screws (not shown) screwed into the sides of the resonator to hold the tongue in place. If the desired

position of the screws does not place them into the center of the resonator sides **2**, additional battens of wood can be attached to the sides of the resonator to provide solid anchor locations for the screws holding down the small block against the tongue.

A hole or slot **12** in the boot box's bottom **5** plays the same role as the slot in the shallot of conventional reed pipe.

3. An Algorithm for Building the Pipe

First, one should cut out and assemble the resonator. This can be done by simply cutting out the proper shapes of the top, bottom, and sides of the resonator, sanding their edges smooth and gluing together. I generally liked to use 1/4 inch (i.e. ~7mm) thick poplar boards for pipe-making; the bottom **5** of the boot box should be thinner, perhaps 1/8 inch (i.e. ~3mm) thick of fairly dense and strong wood (hard maple seems good). Larger pipes may benefit from thicker boards.

Section 4, below, describes an algorithm to produce pairs of triangular pieces with a bandsaw or similar flexible-bladed saw, such as for use in constructing a typical conical-analogue resonator.

For a square pipe to imitate the timbre characteristics of a pipe type normally made in circular cross-section, the following rule must be followed: A rectangular cross-section pipe should be sized so that the diagonal length at a given location along the rectangular pipe equals the diameter at the corresponding location along a circular cross-section pipe of analogous timbre.

The last step in making the resonator is crafting the end-cap **4**. To do this, securely clamp a piece of thin board to the top side of the completed resonator where the boot box bottom 5 will eventually go, and then simultaneously trim both the tip of the resonator and the end of the additional piece which will become the end-cap, to assure the angles match. Finally trim the end of the board off to create the end-cap. Leave the end-cap unattached to the rest of the resonator for now.

Once the resonator is assembled, it is time to start working on the boot box. Cut out the bottom, sides, and top in the usual way for making a little box. There's no need to dovetail the joints or do any reinforcing unless the pipe will be operating at unusually high wind pressure; generous glue during assembly is sufficient. Figure 1 shows fairly accurate vertical proportions: the boot box should be wide enough and long enough to fully cover the exposed portion of the resonator, and high enough to place the air stream entering from the toe well away from the reed tongue.

To size and position the slot **12** in the boot box bottom, first lay the boot box bottom piece against the exposed sides **2** of the resonator and butted up against the top **1** of the resonator just as the boot box will be when assembled, and trace an outline of the resonator profile onto the boot box bottom in ink. Using this outline as a guide, cut the slot **12** into the boot box bottom. I did this by drilling a series of overlapping holes and then using a small model-maker's file to fine-shape the slot **12**. Using very fine sandpaper on a flat sanding block, smooth the area around slot **12**; then smooth it some more by polishing with paper towel. The

key is that the surface that the tongue rolls against should be very smooth and flat. For some reed pipe voicings, the surface that the tongue rolls against may be leathered.

At this time the tongue **11** should be fabricated in the usual way. I used suitably thin brass sheet and a short piece of circular pipe to burnish the tongue to shape. Once the position of the tongue and slot **12** are known, the location of small block **10** can be chosen and marked onto the boot box bottom on the opposite surface from the outline mentioned above.

Next, assemble and glue up the boot box, except do not glue on the top **7** of the boot box just yet. Importantly, the outline of the resonator that was used to size and position the slot **12** should be on the outside bottom surface of the assembled boot box.

At this time, a window may be cut into the top **7** and covered with a leather diaphragm, as described in Elbasani's design referenced in the Introduction.

Once the boot box is dried, craft the block **9** and glue it solidly into place against the bottom and side of the boot box, leaving space between it and the location for small block **10**. Now, glue the top **7** of the boot box onto the rest of the box.

Alternatively, the block **9** can be omitted by making the 'tuning wire' side of the boot box out of unusually thick material which can serve the same function as a separately-fabricated block.

Once the whole boot box with top is dry and solidly glued, there are a few machining steps to do on the boot box before affixing it to the resonator. First, decide on the location of the tuning wire hole. The tuning wire should run as close to the bottom of the boot box as possible, but well clear of the small block **10** and its screws. Standing the boot box on its end, drill the tuning wire hold straight through the side **6** and block **9**. Then turn the boot box over and drill the inlet for the pipe toe **8**. Craft the pipe toe to fit this inlet and glue it into place.

The next step will be to divide the boot box into two pieces. Select a diagonal cutting plane **15** to divide the box. The cutting plane **15** should be quite low and close to the resonator tip on the 'toe end' of the boot box and fairly high on the 'tuning wire end' of the boot box. Cut the box cleanly in two, and carefully sand down the exposed surfaces on the two pieces. Next, craft and affix a gasket **14** to either piece. Re-assemble and clamp the boot box and drill pilot holes for the screws (four recommended) which will hold the boot box together.

Now disassemble the boot box into its two parts, and set aside the top part (with the pipe toe).

Guided by the outline used to size and position the slot **12**, glue the lower part of the boot box to the resonator, being sure to put a bit of glue between the 'tuning wire end' of the boot box and the top **1** of the resonator. At this time, also glue the end-cap **4** to the boot box bottom and to the tip of the resonator. One or more strong rubber bands can be used, looped around the end-cap **4** and the opposite side **6** of the boot box to secure the end-cap while drying.

Clamp everything securely and allow to dry well.

To avoid damaging the tongue's contact surface or putting uneven strains on the thin boot box bottom, I recommend using three clamps: (1) a clamp spanning from the top of the block **9** to the bottom **3** of the resonator (2) a clamp spanning from the (temporarily placed) top of the small block **10** to the bottom of the resonator and (3) a clamp spanning from the top of a large smooth temporary block placed over the entire region of the bottom **5** where the tongue will be located to the bottom of the resonator. It's very important to not allow the clamping process to dent or mar the surface against which the tongue will roll!

After the assembly is dry, it's time to finish the internal work in the boot box and resonator. Remove all the clamps. Begin by placing a piece of masking or painter's tape tightly over the slot **12** and pour some thin sealing liquid (such as shellac) into the resonator, slosh the liquid around to thoroughly coat the inside of the resonator, pour the liquid out, hang the pipe upside down to let any residual liquid trickle out, remove the piece of tape, and leave the whole pipe hanging upside down to dry thoroughly. (We do not want sealing liquid to pool and dry in the resonator tip, clogging or dribbled through the slot!)

If extra air-tightness is desired, the inside surfaces of the boot box, except the reed tongue contact surface, may be painted lightly with sealing liquid.

The final steps involve the installation of the reed tongue. First, very securely and tightly tape the small block **10** in place, and drill the pilot holes for its screws through the block, boot box bottom, and into the sides of the resonator (or battens attached to the resonator sides). Then install these screws. Fabricate the tuning wire **13** in the usual way (I liked to use brass wire for this) and thread it into the hole through block **9**. Finally, loosen the small block **10**, slip the tongue **11** into place, tighten down the small block to secure the tongue, and carefully position the tuning wire to bear against the tongue.

Once any adjustments to the tongue curvature are made, the two pieces of the boot box can be screwed together securely. At this point, the pipe is complete, ready to be tuned, voiced, and placed on its value-chest.

Figure 2 shows a photo of such a pipe, although as a test pipe the screws attaching the two parts of the boot box are not included. Notice the small wood battens added to the sides of the resonator. The block **9** was installed after dividing the boot box, an order I now consider sub-optimal.

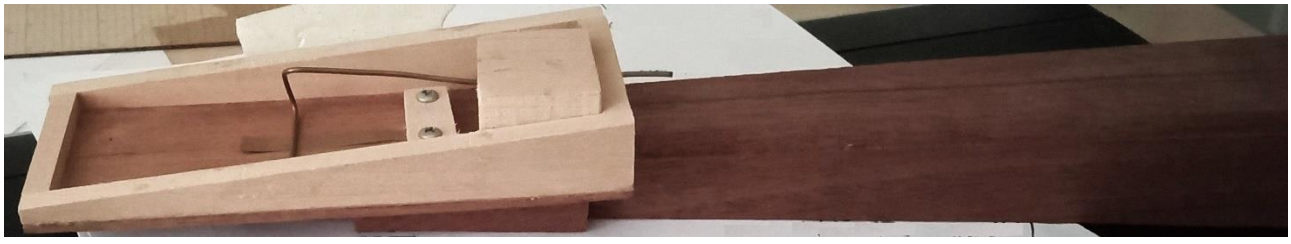

Figure 2

4. An Algorithm for Making Triangular Pipe Pieces on a Bandsaw

For cutting out a pair of matching triangular pieces on a bandsaw for making pyramidal pipes (e.g., tapered reed resonators, but also gemshorns, spire flutes, etc.), here is an algorithm

1. On a large rectangular straight-sided board, draw the triangular pieces, a bit oversize and oriented to point opposite directions

2. Using the fence of the bandsaw as a guide to assure the two still-connected triangular pieces have parallel straight external edges, cut out the two still-connected triangular pieces from the larger board

3. Cut along the line between then triangular pieces; taking advantage of the fact that bandsaws tend to wander a bit, don't try to cut straight along this line, but cut a slightly curved path to make one triangular piece slightly concave and the other slightly convex

4. Take the two triangular pieces, and tape them together securely along their straight sides, so that you have a combined rectangular piece with one convex and one concave side.

5. Adjusting the bandsaw fence appropriately, place the concave side of the combined rectangular piece against the fence and trim off the convex side to make that side of the combined rectangular piece straight.

6. Once again adjusting the bandsaw fence appropriately, place the now-straight side of the combined rectangular piece against the fence and trim off the concave side to make that side of the combined rectangular piece straight.

7. Disassemble the two triangular pieces - all four edges are now perfectly straight, ready for sanding smooth and gluing up.

5. Reference

[1] https://www.mmdigest.com/Gallery/Tech/elbasaniTrumpet.html “Simplified Reed Pipe Construction” by Marc Elbasani