

# **Notes on making a large overtone flute (the Fujara) from readily available materials**

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What follows applies solely to an instrument in the Key of G to avoid confusion. The G is a popular size and despite its five and one half feet is manageable. An important aspect is that it will fit into an average sized room without hitting the ceiling. With an F, a foot longer, this is not the case. The fipple dimensions and voicing for the G will also drive both an A and an F. I have broken the design into three equal pieces for convenience in transport and to minimize material loss in the holes section if tuning does not go well. Only this section will need to be replaced not the whole thing. I feel this encourages freedom and experiment.

### **Stuff you are going to need:**

- A ten foot piece of 1-1/4" schedule 40 PVC pipe. Cut this into 4' & 6' so you can get it home.
- A ten foot piece of 1/2" CPVC--(the yellow stuff). CPVC is lighter than the 1/2" PVC and weight is a consideration. How you cut is unimportant as it will end up in a lot of short pieces i.e. mouthpieces.
- A can of PVC cement. Look for the small ones and opt for clear as the orange stuff makes an ugly joint. The plumbing folks did not have aesthetics in mind with their products.
- This next entry is problematical. You are going to need a 1-1/2" inch piece of 1-1/2" PVC. To purchase a whole piece of 1-1/2" does not make sense. This piece can be made from a 1-1/4" coupler by knocking out the ridge inside with a chisel or prowl construction sites for scraps or simply ask a plumber for left over pieces. While you are at it a 2' piece of one inch might also be useful though a piece of broom stick will do.
- A four foot piece of Timberon 1-1/2" closet pole(LTM 232) At first I thought this stuff was wood until it melted under my saw. It is recycled polystyrene and perfect for the fipple as it is inert and will not swell, shrink or split like wood.
- A 1-1/4" pipe cap, Two 1-1/4" couplers-three if you can't find a short piece of 1-1/2", a 1/2" 90 degree elbow , a 1/2" T and two 1/2" couplers.
- A small bottle of super glue preferably the stuff called GAP which has a goeey substance to it and 10 minute Epoxy, the kind that comes in two tubes.
- Sandpaper- particularly 200-400-600 fine for polishing the windway.

### **Tools:**

- A vernier caliper. A simple ruler is not accurate enough.

- A small wood rasp (6") .This is not a chain saw file but a rough cut file.
- A small C-clamp
- A vise. It doesn't have to be big or good. Just so it will hold.
- A box knife with new blades and an Exacto knife with the very oblique triangular blade also NEW = sharp. Sharp-sharp-sharp-or die!
- A ten inch piece of .062 music/piano wire. This is to make the gauge to establish the windway height. Again Prowl! Model airplane shops stock this stuff and if you are lucky older hardware stores. Small Parts Inc. sells it, but in lifetime supplies. The problem is you really need this wire. As if this were not enough you can't cut or file it. It has to be ground.

I think a tuning utility of some sort is a must. Digital tuners i.e. Korg are cheap these days and there are a number of these on the computer. I found TUNE-IT to work the best for me. You can use it for 30 days free. If you struggle with tuning for that long you will end up in an institution anyway.

Regular machine drills will work but a 1/2" Forstner bit would be nice for the finger holes.

Despite this rather long list most of it is inexpensive and available from Home Depot and you don't have to buy it all at once.

## The Fipple - The big whistle

The word fipple is an archaic expression for a plug. It has become synonymous with the entire voicing system of this kind of flute which includes the windway, window and labium, terms I will use as I go along.

Cut a two inch piece of the Timberon closet pole. This will be the fipple or plug. You will see that it is a tad too big to fit inside the 1-1/4" tube. This is good as it is easier to shave something down to fit than to try to make it bigger. The man made nature of the material allows it to be shaved or scraped. The box knife (new blade) will scrape a very fine shaving almost like a plane. Put on some music and start scraping. This will take about  $\frac{3}{4}$  of an hour. Turn it end for end and periodically sand it on a flat surface. The scraping takes out more in the middle than the ends and sanding counters this. Carefully fit this into the piece of 1-1/4" PVC you are going to use for the fipple end. This piece is 22" long-the other two pieces are 23" (the pipe cap adds the missing inch to make the three pieces equal). The object of the fit is that it fits with NO force. PVC is more flexible than you realize and force will spread the channel that will be the windway making it hard to fit the cover (top of the windway). It should have just enough friction to hold the fipple in place so it won't slide down the bore but with not enough pressure to deform the PVC. The fit should be tailored to each piece and end of PVC individually. As the absolute last step the fipple will be glued in place with the super glue.(NOT NOW!)

With the fipple fit it is time to cut out the windway . The windway is two inches plus the window. The window is 13.5 mm x 11mm. So the total is two inches plus 11mm. 13.5mm is the width of the windway. When you have measured this out and marked it on the tube make two little impressions in the middle of what will be the window. Use something sharp pointed or a tiny drill. This is so the next larger bit will not skid. 3/16" is about right for these two holes where the window will be. The holes are so ,when you have sawed to this point, you can get the resulting slip (will be the cover or roof of the windway) out. Be very careful not the hit the sides of the window when you drill or the dimension will not be 13.5 mm anymore.

You can now wring the slip out This leaves a ragged hole just in front of the labium edge. With your box knife carve this straight. If you can keep the window depth slightly small i.e. 10mm so you have a little slack(1mm) to cut the window larger if required. At the same time cut the ramp leading away. Because the PVC is thin almost any angle less than 45 degrees will work. At first keep the sides of this ramp (width of windway) parallel. Latter you can fan the sides out concealing your clumsy knife work rather than any acoustic advantage.

Now the tricky part!

With the fipple out and a new blade in your Exacto knife reach into the windway slot and carve a small sliver from under the labium inside the tube. The object is to raise the edge of the labium so it bisects the ribbon of air generated by the

windway. The ideal is 1/3 of the windway below and 2/3 above. The windway is .062 (1/16") high. The edge of the labium has a dimension of about 1mm so you can see this is very close and you are going to have to guess at it. All I can say is try to imagine the 1/16" and what you are doing to it in your minds eye. The labium edge has to have a dimension (not sharp) or the high notes may not sound. Somebody once told me a "pencil line". If you reinsert the fipple and tape over the open windway the whistle will sound but will use a lot of air because it is unconstrained. The last step is the windway cover.

If you have been lucky the piece you cut out for the windway will also serve as the cover or roof. It will be narrow by two saw kerfs. If you butter one edge of this slip with epoxy this missing dimension can easily be replaced. If you sawed the windway too narrow and had to scrape to get to 13.5mm you may have to make a new cover. Again when fitting this cover do not force it ! If you do it may spread the windway sides and the fipple will drop down the bore. The cover should be sanded to just sit comfortably in the channel. The height will be determined with a gauge made from two pieces of .062 (1/16") Music/Piano wire 4" to 5" long. To make this gauge I drilled two 1/16" holes in a scrap piece of PVC that had an outside dimension of 13.6 (the windway). They were glued with Epoxy so I could pull strongly on the two pieces of wire in case they got stuck. This parallel wire gauge rests inside the windway and supports the roof at a perfect .062. With a small (2") C-clamp I put a gentle pressure on the roof to hold it all together. The gauge serves two functions First it stops the epoxy we are going to apply from leaking down into the windway and second if the wire is waxed it will serve as a release if it does. Glue has a perversity that brings it always to be where you don't want it Now glob the whole thing liberally with Epoxy. This is only a temporary tacking job as epoxy doesn't stick well to PVC. The cover will actually be sustained with the epoxy paste/putty fillet formed in a channel above the roof. This channel is a 1/2" strip cut from the mysterious 1-1/2" piece of PVC and snapped and glued over the 1-1/4" body.

Once again remove the fipple but this time mark it's position so it can be replaced from whence it came. Cut a chip/wedge from the side of the fipple that starts a midway (1") and drops about a 1/4". This serves as an air compression strategy on the way to the fipple. It will work without this wedge but it increases resonance power dramatically. Sand with fine sandpaper the one inch area that will be the floor of the windway. It should be shiny as possible. Look down the open windway and check carefully for little globs of glue that may have found their way there. Remove them. The one inch of windway should be aerodynamically perfect. Two tiny chamfers remain, one on the cover of the windway where it enters the window and the other on the edge of the fipple where it enters the window. These are on the order of 1mm. Replace the fipple and you have a musical instrument!!!  
Play Taps.

## Tube Tuning - Tuning the Tube

With the fipple assembly almost (note almost) complete the tube will speak. In theory the overtone series is whole number multiples of the fundamental in a rising series of intervals. The first problem is that in the "real world" this turns out to be not quite true. I think with simple folk instruments that a small amount of pitch variation is i.e.. five to ten cents is permissible. After that things are becoming pitchy. Listen to the tube and become familiar with it before any holes are drilled. When you blow very softly, a smoke rings worth, you may hear what is technically the pedal tone. This is the lowest possible sound from a tube of given length. It is a very low hooting sound that is almost inaudible. It will be a slightly flat G. Blow a little harder and you are in the next octave up, also G. This is called the "mumble rank" because the first four tones are very quiet and distinctly lack power. Unfortunately a great deal of music dips down into these first four tones so they must be there. It is four tones up in this second octave that the most used tones start. This is the tone D. There is a third octave if you blow harder and it is here that the G must be spot on if you are looking for accuracy of tuning. (International standard of A=440 Hz) By the way the tube doesn't care much about this standard.

The rules of tuning are:

Shorter is sharper.

Bigger is sharper.

Flatter is the opposite.

So if you want to sharpen a hole raise it up the tube and enlarge it. To flatten a hole move it down the tube and make it smaller. A general rule of thumb is that a one half inch hole is about all that can be reliably closed with a human finger. This can be stretched by making the holes oval. Study carefully how your hands will rest on the tube and make the ovals match your fingers but there is a limit here and now the hole must be moved (down).

Now that you are friendly with the tube itself and think it blows a useful G it is time for the first hole (A). If the tube is flat cut a little off and if sharp add a ring of PVC on the bottom. The first time I did this I found exactly where the A should go. It was a strong, clean, robust tone and exactly 440 Hz. The problem was the E, also required from this hole was wildly and unusably sharp. What I had stumbled on was that the A overtone series was NOT in tune with itself! The only strategy left was one of compromise. I had to move the lovely A down (flatten) to modify the sharp E. I opted for an imaginary point at which the A is just as flat as the E is sharp (about 10 cents). This anomaly appears in all my attempts. It may have to do with the length of pipe below the hole. The next hole B is similar but easier to correct. The third hole (C) turns out not to be C at all but E! E is a problem tone as it wants to be chronically flat. E is the second tone asked of the third hole. If it is slightly too high it will speak accurately but it's resonance slips off and it stops. If you find this move the hole down. Tune for the E as the C can be arrived at with various fork finger configurations. At this point in the scale you have three open

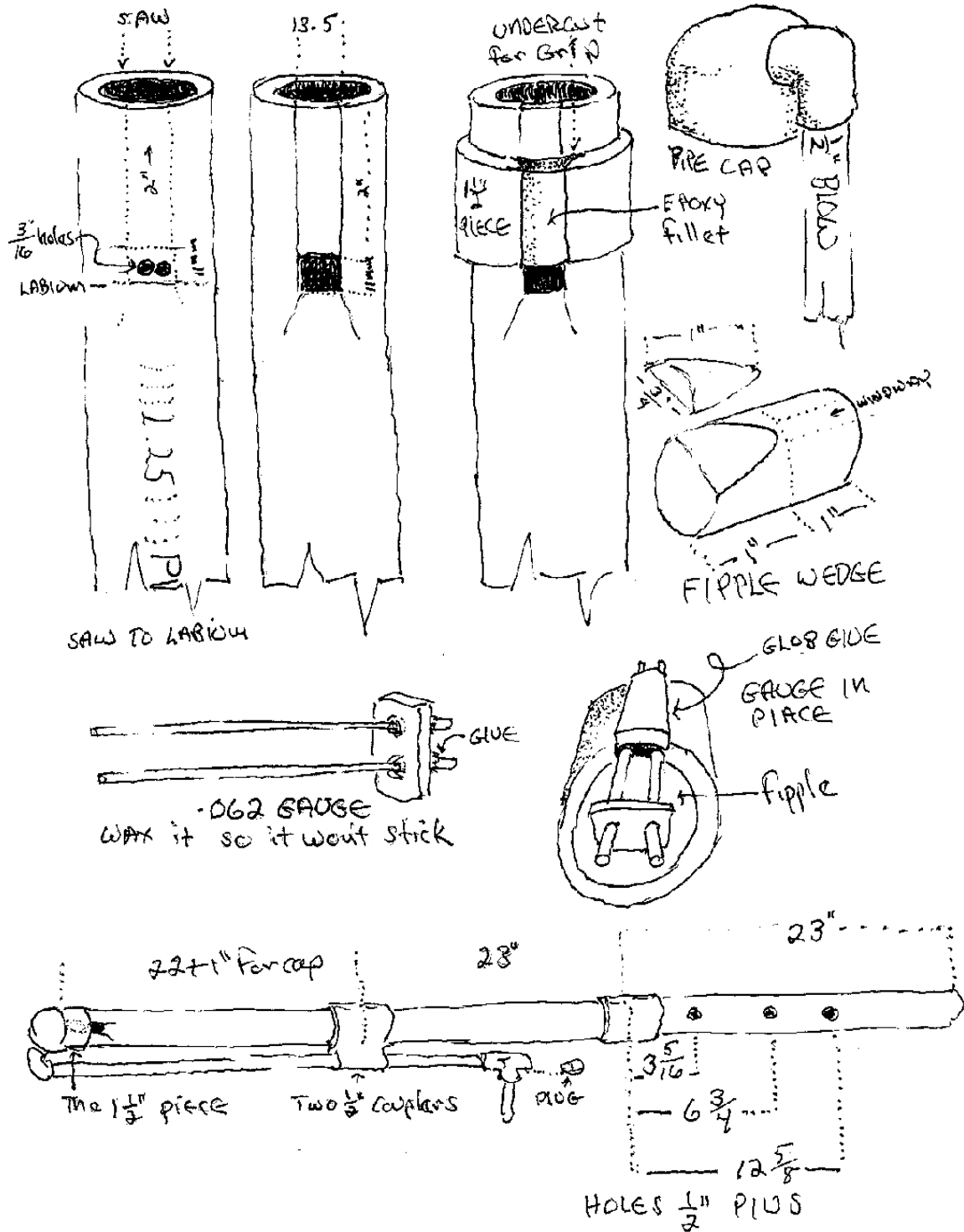
holes available to make a C-use them . It is possible with patience to tune the PVC solution very accurately and consistently.

Now for the last step. Stand the fipple section on it's head leaning slightly and put a few drops of super glue through the window. Roll the drop from side to side sealing the area between the inside wall and the fipple. Do NOT get glue in the windway! The idea is to seal and create a small acrylic wall so the fipple can not go down the bore. It is unlikely that it will jump out at you.

The hole positions are:

From the top of the bottom 23" section:  $3\text{-}5/16\text{"}$ =C/E,  $6\text{-}3/4\text{"}$ =B,  $12\text{-}5/8\text{"}$ =A. The holes are all bigger than  $1/2\text{"}$ . The total length for a G is 66 inches plus or minus a tad. You have to listen for this length. You will have to enlarge each of these holes with a rasp and undercutting to achieve perfect pitch. This last section is not sacred. If you butcher it there is still left over pipe. Cut a new one and start again.

# Sketches - These are worth a thousand words!





## Miscellaneous

As you can see from the illustration the 1-1/4" pipe cap fits onto a sort of tenon above the 1-1/2" piece. This tenon is 1/2" high. The roof of the windway sticks up above the radius of the 1-1/4" pipe by .062 (1/16"). This must be scraped down for the cap to fit. This is also why not to force the fipple or the windway cover as this will not allow the pipe cap to fit. I have made this cap removable for cleaning and hygiene reasons. Drill a 5/8" hole, being sure to leave clearance for the height of the tenon. This will accommodate a short piece of 1/2" CPVC that will reach clear across the inside of the cover touching the far side opposite the hole. This takes some carving and be careful that it emerges at 90 degrees to the cover or the blow tube will have to be bent to connect below. This is all to give the 90 elbow gluing strength. I drill a few holes that seem to equal the ID. of the CPVC on what will be the TOP. When you look into the cap you can not see these holes. This acts as a water trap forcing condensation back down the blow tube, keeping it out of the windway.

Because there are no fibers in PVC fluted machine drills tend to grab. This happens with surprising suddenness and you can drill clear through the other side. Start with a small drill and work up to big with four or five steps. Put a 1" piece of PVC or the broomstick inside as a buffer .The drill that is recommended is the Forstner bit but they are expensive.

To determine the height of the mouthpiece hold the tape measure in your mouth and pull it down to your ring finger .The stretch should not be extreme.

Acetone takes the printing and codes off the PVC easily. Paint does not work well on plastic as it tends to chip. Krylon and Rust-o-leum produce specially prepared formulas that work well on plastic. It is primarily for outdoor furniture and tough. You can finish your project from conservative black to florescent orange if you choose. Anything is better than fish-belly white of PVC.

At the mouthpiece end is the PVC T fitting .The bottom of the T is plugged with a 1/2" plastic chair leg tip held by a piece of string. It is amazing how much moisture this produces. In short this serves as a spit valve as in brasses. A 90 will work but you will have to tip it to get the moisture out.

Cutting things square i.e. 90 degrees is nice but not absolutely essential. A miter box either store bought or home made will help.

Take care when assembling that the sections are closed or it will be too long and flat. A rap on the (carpeted) floor will do this.

If a hole is in the wrong place simply tape it and drill another. When satisfied transfer what you have learned to a fresh piece of pipe. Holes can be invisibly

repaired by chamfering the inside and out to provide a flange to grip epoxy paste/putty. Back the patch job with a well greased piece of 1" PVC. For the difficult holes I cut a tube section that had an ideal hole already in it .Above and below this I cut a number of narrow slices. By exchanging the slices I could effectively move the hole up and down. I taped this all together with scotch tape and transferred what I found to a fresh piece of PVC.

Epoxy putty or paste is a two part product that comes in a number of forms. One is a roll that looks like taffy candy. You cut a chunk off and roll it between your hands to mix the resin and the hardener. I t can be carved and sanded when it sets. Epoxy paste is the same thing but gooier. Plumbers putty is also the same stuff. These products can be found at the glue display in most hardware areas. The high priced stuff is Magic-Sculpt.

Last , I have concealed this by putting it at the bottom, if the fipple does not behave, it is a very finicky system, all is not lost. Cut six inches off the top of your project and make a new six inch fipple and add another coupler. Actually I have toyed with the idea of starting this way and simply making a number of fipples searching for the "best" one. With musical instruments some work better than others and offer no explanation. An interesting part of this project is the parts are interchangeable.