

# PAL mkII Fabrication Notes

by Bill Conkling (NR4C)

For those who have a desire to duplicate my latest efforts at building the latest Pneumatic Antenna Launcher, I am providing these notes. While this is not a complete "How to" tutorial, I think I can cover the basic idea behind the process so that anyone with moderate skills can reproduce the launcher with assurance that it will perform as expected.

First, let's look at what materials are needed for the PAL mkII.

| Item #            | Item                                  | Quantity | Used For                                     | Lowes          | Home-Depot     | Ace            | Cost |
|-------------------|---------------------------------------|----------|--|----------------|----------------|----------------|------|
| PVC <sup>10</sup> |                                       |          |  |                |                |                |      |
| 1                 | 1 1/4 X 24                            | 1        | Barrel                                       | Y <sup>3</sup> | Y <sup>3</sup> | Y <sup>3</sup> |      |
| 2, 23             | 1 1/4 Coupling                        | 2        | Join Barrel to pipe adapter and REEL adapter | Y              | Y              | Y              |      |
| 3                 | 1 1/4 SLIP > 1" pipe (Female) adapter | 1        | Convert to 1" Pipe                           | Y              | Y              | Y              |      |
| 4, 6              | 1" pipe (M) > 1" SLIP (F) Elbow       | 2        | 90 deg bend                                  | Y              | Y              | Y              |      |
| 5                 | ~12" of 1" tube                       | 1        | Various joints                               | Y <sup>1</sup> | Y <sup>1</sup> | Y              |      |
| 7                 | 1" Pipe (M) > 1" SLIP (F) adapter     | 1        | Join valve to tank                           | Y <sup>2</sup> | Y <sup>2</sup> | Y              |      |
| 8                 | 1" > 2" SLIP/SLIP adapter             | 1        | Join valve to tank                           | Y              | Y              | Y              |      |
| 9                 | 2" SLIP/SLIP coupling                 | 1        | Join valve to tank                           | Y              | Y              | Y              |      |
| 10                | 2" X 24" Tube                         | 1        | Tank   | Y <sup>3</sup> | Y <sup>3</sup> | Y <sup>3</sup> |      |
| 11                | 2" Cap                                | 1        | Tank cap                                     | Y              | Y              | Y              |      |
| 12                | 2 X 2 X 1 TEE                         | 1        | Strut  | Y <sup>^</sup> | Y              | Y              |      |
| 13                | 1 1/4 X 1 1/4 X 1 TEE                 | 1        | Strut  | Y              | Y              | Y              |      |
| Hardware          |                                       |          |  |                |                |                |      |
| 14                | Orbit Sprinkler Valve                 | 1        | Valve  | Y <sup>4</sup> | Y <sup>4</sup> |                |      |

|        |                                    |       |                                    |                |   |                |     |
|--------|------------------------------------|-------|------------------------------------|----------------|---|----------------|-----|
| 15     | 1/8 " Pipe Schrader Valve          | 1     | Inflation port                     |                |   | Y              |     |
| 16     | 1/8" pipe Pressure Gage            | 1     | Pressure gage                      | Y <sup>5</sup> |   |                |     |
| 17     | 1/4: pipe Street Elbow             | 1     | Join release nozzle to valve body. | Y <sup>6</sup> |   |                |     |
| 18     | Air Nozzle <sup>7</sup>            | 1     | Firing device                      | Y <sup>7</sup> |   | Y <sup>7</sup> |     |
| 19     | ZIP REEL                           | 1     | Line Reel <sup>8</sup>             |                |   |                |     |
| 20     | 1 1/2" X 12 X 0.06: Alum or Brass  | 1     | Bracket for Reel <sup>9</sup>      |                |   |                |     |
| 21     | #8 X 1/2" SS screw/washer/lock-nut | 4     | Attach reel to bracket             | Y              | Y | Y              |     |
| 22     | #10 Nylon Screw                    | 2     | Mount bracket to barrel coupler    |                |   | Y              |     |
| Bullet | 3/4" PVC Cap                       | 2 per | String Weight                      | Y              | Y | Y              | .50 |
| Weight | 1 Oz Egg sinker                    | 1 per | Add weight                         |                |   |                |     |
| Eye    | 'small Screw Eyes                  | 1 per | Attach line                        | Y              | Y | Y              |     |

NOTES: (Be aware that PVC part availability varies from time to tome at each location.

1. Minimum length at Lowes/Home Depot is 5 foot. Ace will sell short lengths by the foot. One foot will make all the short (2 or 3 inch each) slip joiners.
2. Check your valve box, mine came with two of these adapters, from Lowes. The Orbit valve from Home Depot does not.
3. Lowes/Home Depot sell short 24" sections, ACE sells it by the foot.
4. This is the valve I used, it's cheaper than the RainBird and is easily modified for use in this device. See note 2 also.
5. I did not check other local stores, I found this at Lowes as part of a pressure adjustment device, and the cost was less than some mail order sources when you added in the cost of shipping. I just removed the gage and threw away the rest. I prefer a gage with the fitting in the 'center back' as opposed to the side mount.
6. This is a small brass item with a 90 degree angle, and male pipe threads on one end, and female on the other.

7. I saw one of these at ACE, but decided to look elsewhere for a different style. While at Lowes, I saw a similar device to the one at ACE and saw it on a special for just a couple of bucks, and bought it.
8. The ZIP REEL is made for Bow Fishing, and is not available from local sources. I found it at the manufacturer's web site and called to order. Very friendly people and they responded quickly. The reel comes complete with mounting bracket for your bow and some string. You will not need either, so when they ask whether you want it for a left or right hand bow, just tell them it doesn't matter. The web site is <http://www.sausa.com> or call them at 1-800-228-1408. The cost is around \$37 or about what you would pay for a decent quality fishing reel, and this is much smoother in operation and less subject to miss-fires.
9. This is custom bent to mount reel to barrel coupler. Nothing critical, just follow the drawing included in these notes.
10. All PVC components are made from Schedule 40 PVC and are rated for pressure. Do not be tempted by similar looking parts made for waste and drain applications, they are not rated for pressure. Look carefully.

You will need some basic tools and materials for working with the various materials in this project. Get fresh PVC Purple Primer and Glue for the PVC joints. Don't scrimp on this. Use the primer and glue on both surfaces, and have enough insertion length to get solid joints. I cut my joiners just a bit shy of the total insertion length so that I could get minimum growth in the joints.

For cutting the PVC, I have found the correct tool makes it easy. I use a Marple saw, about 7" blade that cuts on the PULL stroke. Mine came from Lowes and friends jokingly refer to it as a "Ginsu" knife. It has fine teeth with minimum 'set' to leave a very narrow kerf. I mark the tube with a Sharpie and try to cut on the line.

When gluing the PVC parts together, I found that using a file or sandpaper block to slightly bevel the edges makes it easier to insert one part into the other. Dry fitting is a good idea, but be careful, as sometimes it is possible to get the pieces stuck very tightly and it takes a lot of effort to separate them.

Be sure and use the "Purple" primer on both parts and let it dry. When ready to glue, apply to both parts and quickly insert the smaller piece with a twisting motion until it is seated fully. Hold for a few minutes and move on to the next step.

You will need some 1/2" Teflon™ pipe tape to seal the pipe threaded joints.

For the valve modification process you will need a dime, and a toothpick and a drop of "Superglue" or some form of CA adhesive (Cyanoacrilate). You will also need a small quantity of a good quality, s-l-o-w setting epoxy, preferably one that's rather thick. **J-B Weld™** works well for this. **DO NOT USE** a 5-Minute variety epoxy for this. These fast curing adhesives are not good for long term use and will fail in time. They frequently don't get 'rock' hard and will get soft and spongy if stored outside or under hot conditions. *(Note: I will assist you with this step if you ask as I already have the materials - you supply the dime- and there is no need to buy a kit for this one use.)*

You will also require a 1/8" pipe tap and a 1/4" pipe tap to tap holes for pipe fittings. And, don't forget the required drills for pre-drilling the holes for the raps and the mounting screws. You will also need a 10-32 tap to tap the mounting holes in the reel-barrel coupler to mount the reel

And, last but not least, "Read, understand and follow" all safety rules supplied with you tools and materials, and use of safety glasses is recommended. The adhesives used in this project give off nasty fumes so work in a well ventilated area. When using the 'Ginsu' knife, be especially careful as it is very sharp and can make deep cuts before you know it.

## Now on to the assembly....



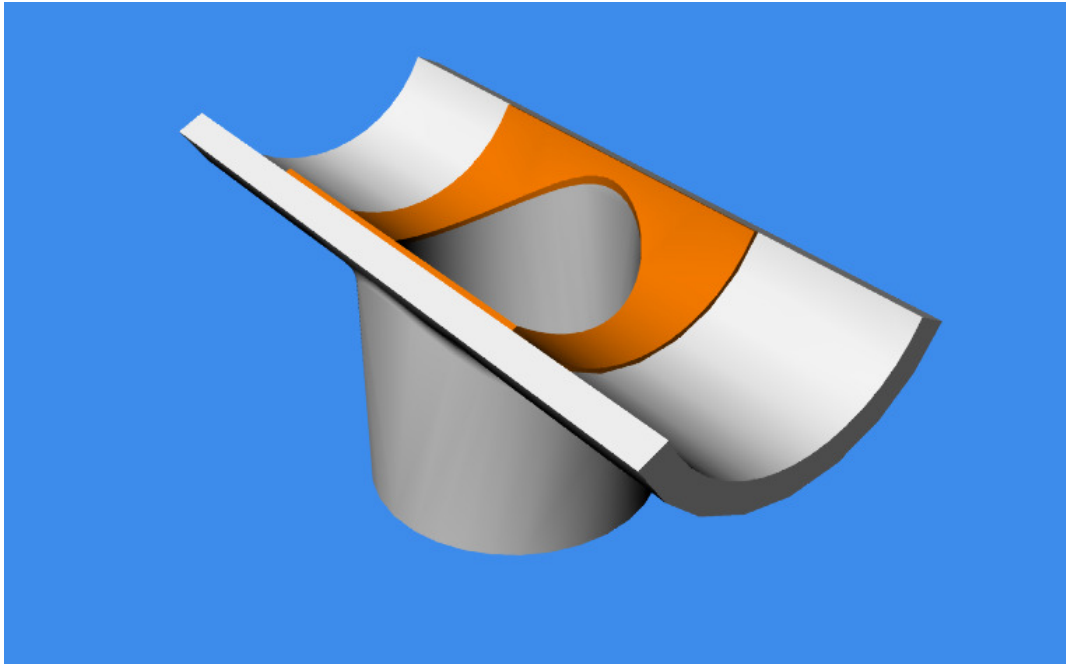
Starting with the barrel, I used a 2 foot length of 1 1/4 inch Schedule 40 PVC from Home Depot as is. The tank was cut from a piece of 2" pipe from Lowes, however, don't cut it yet as it's length is dependant on the overall length of the barrel assembly. Here the pull saw was perfect for the job. You can assemble parts #1, #2 and #3 at this time.

This is also a good time to glue the coupler part #9 to the tank part #10. This joint needs to dry well before drilling and tapping for the pressure gage and tire valve., parts #15 and #16. Be sure to clean out any debris inside the tube after drilling and tapping the holes.

Now assemble parts #7 and #8 with a 1 7/8" length of 1" pipe (part #5b). It appears that most of the PVC slip fittings allow for a 1" insertion so the max length for a joiner would be 2". I don't cut real straight, or perpendicular with hand tools, so I usually cut the joiners about 1/8 to 1/4 inch short of the max length.

Now let's make up the strut to hold the barral and tank in alignment. This is probably the most work of the entire project. You'll need the two TEES. The 2 -2-1 (#12)is for the tank, and the 1 1/4 - 1 1/4 - 1 (#13) fits the barrel. Cut a almost 2" length of the 1" pipe and prepare it for gluing by beveling the ends and priming. Put glue in the 1" hole in the LARGE TEE (part #12) and on one end of the 2" long joiner. Quickly insert the joiner as far as it will go. Use a twisting motion the spread the glue and make insertion easier. Let this dry for a few minutes, and then put glue on the remaining joiner end and inside the 1" hole in the other TEE. Push together firmly and make the two TEE legs butt against one another. Lay on the bench and make sure the straight sections of TEES are aligned and parallel.

The cuts on the TEES to remove the un-needed portion are not critical here, just try to make it look neat and symmetrical. Draw a line with your Sharpie straight along each side of each TEE just below the filet. Now hold the TEE firmly on your bench and cut along the line with your pull saw. This goes pretty fast. Now, examine the picture below and remove the colored area on the 'inside' of the straight section of the TEE. Here a rasp, Dremel, sandpaper on a dowel or any other idea you may have will work. Just try to get the entire length of the TEE smooth and well fitted the the respective pipe section. I got impatient and did not do a very good job of this. My attic shop is HOT, HOT, HOT and I couldn't stay up there too long.

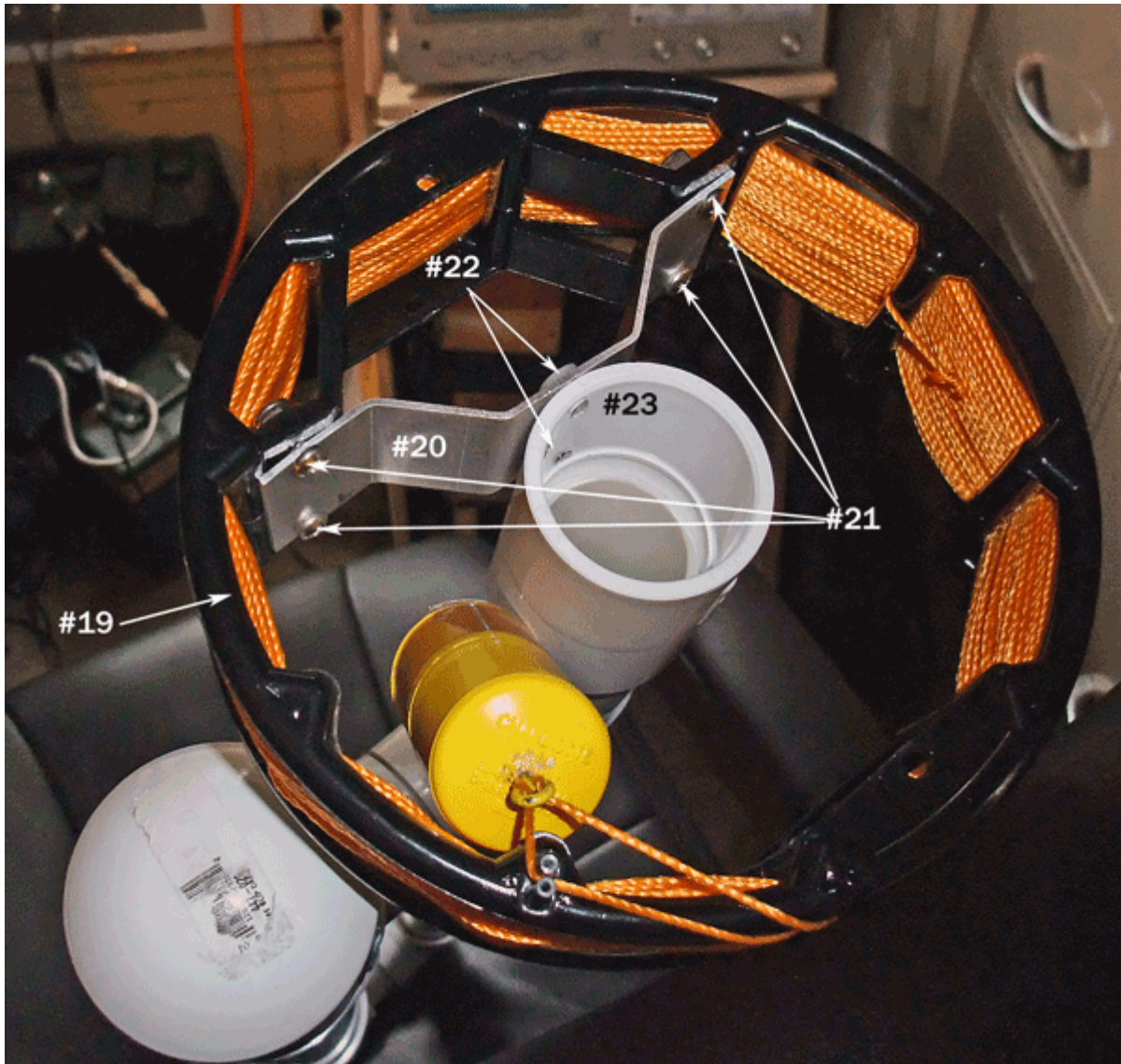


The next assembly is the two elbows (part #4 & part #6) and joiner (part #5a) to make the "U" turn between the valve (part #14) and the barrel assembly. Here is where I have deviated from my prototype. The parts list calls for part #4 and #6 to be alike. I like this better as it makes this assembly easier. And, it will allow you to change the barrel. Whatever you do, make sure part #4 matches up with part #3. To assemble these two elbows, you will need a joiner of 1" pipe (part #5b) that is about 3" long. Place the strut on the bench and lay the barrel and tank with the various adapters dry fitted to get an idea of the required joiner length at part # 5b. Ideally the tank and barrel will be parallel. Cut to length and prep and glue similar to the strut assembly making sure the two legs of the 'U' are parallel to each other and lay flat on the bench top.

Assemble the various assemblies at this point. You can glue the barrel to the "U" assembly (or apply Teflon™ tape and screw it on). Using Teflon™ tape, attach the valve to the "U". Make up the adapters between the valve and the tank tube, but don't put the tank or the cap on yet. Make sure all threaded joints are tight and have the Teflon™ tape. Be sure the gage and tire valve are positioned as you want them, and glue the tank to the assembly. Now mark the tank at the end for cutting. The tip of the cap must be a least 1/2 inch shorter than the end of the barrel. A bit more would be better. This allows for the string to fly off the reel without getting snagged by the tank.

## Now for the ZIP REEL...

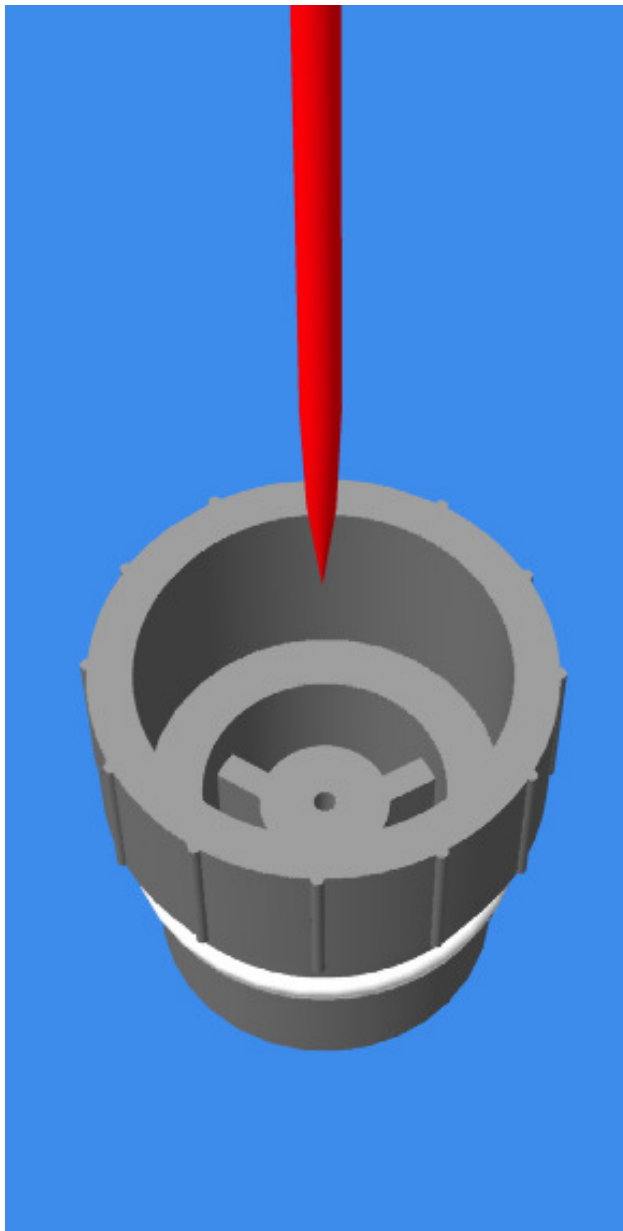
Refer to the photo below to get a feel for the reel attachment. I used a strip of .060 T6 aluminum about 1 1/2 wide to make the bracket. Anything around that size should do fine. I mounted the reel to the very forward end of the coupling (part #2) to move the reel out as far as possible. I also allowed the mounting screws to be in the outboard section of the coupling, and they wouldn't interfere with the coupling fitting on the barrel. The nylon screws are soft enough to cut with 'flush' wire cutters.



I think that about does it for the launcher itself. The next step is the mod to the solenoid adapter and the valve mods.

I am still not sure what line to use, but it works well the standard Mason's line avail from Lowes. But it doesn't slide thru the trees very well. Will probably go back to some 12 lb or so monofilament.

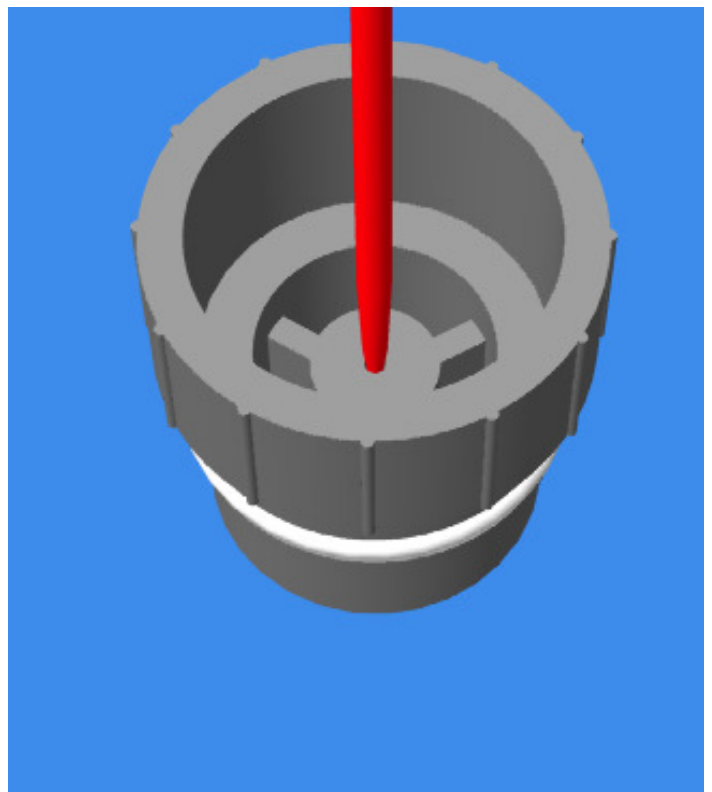
## The Solenoid Adapter Mods....



Refer to the rendering at left to get an idea of what is needed here. The small hole in the cylinder in the center of the adapter is the orifice that allows the air above the diaphragm to escape allowing the valve to "open" when used with the electric solenoid. The solenoid plunger blocks this small hole until it is energized by the battery voltage.

We have to block this hole so air from the tank can't get through. We also have to block the entire inner volume of the lower section (up to the 'shelf') with something to seal it.

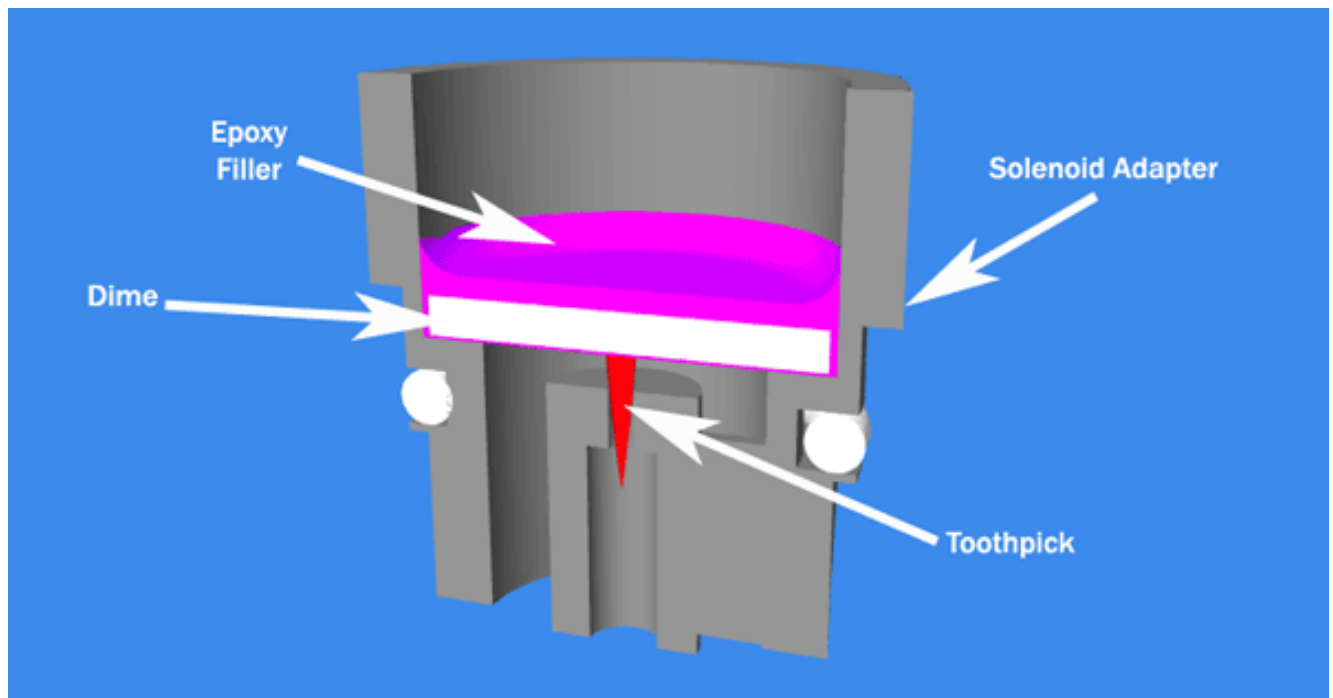
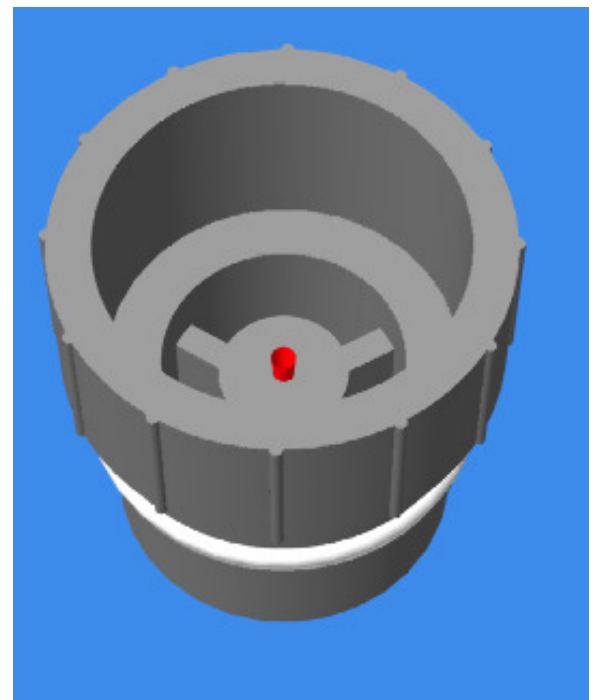
First we need to insert a toothpick into the hole as a plug. Use a drop of CA adhesive to bond it in place (*Below*).



Next you need to cut the toothpick off level with the shelf inside the adapter. For this, I used a nail clipper. Be careful, try not to cut it too short, but if it is too high, the next step will be more difficult. The next picture shows the toothpick cut to the correct height.

Now comes the fun part. We need a solid disk to fit inside the adapter body, lay flat on the shelf, preventing the toothpick from moving and forming a base for some epoxy to bond it all together and seal everything up tight. A dime is just the right size. I filed the mill marks off the edge of a "Roosevelt" dime and it fit perfectly into the cavity. I mixed up a small quantity of "J-B Weld" and applied a small drop on top of the toothpick, a layer on the shelf, and dropped in the dime. I poured the rest into the cavity on top of the dime and rapped it hard several times on the table top to dislodge any air bubbles so then could rise to the top and let it cure for 24 hrs.

The picture below shows a cross-section of the finished adapter with the 'O' ring, the adapter body, the dime and the epoxy filler, oh, and don't forget... the toothpick.



The last thing to do to the valve is to drill and tap the hole for the street elbow and air nozzle release mechanism. Remove the screws holding the valve body together and lay them aside. Now, carefully separate the two halves of the valve being careful of the diaphragm. Make a mental note or a sketch so you'll know how to reassemble this part. Be gentle, and remove the diaphragm and lay it aside. Now you're going to drill a hole in the center of the upper part of the valve body. Now align the 1/4 NPT perpendicular to the valve and tap the hole. Go slow, test frequently as you don't want to go too deep. When the hole is tapped deep enough, apply several wraps of Teflon tape and screw the nozzle into the street elbow and then screw the whole



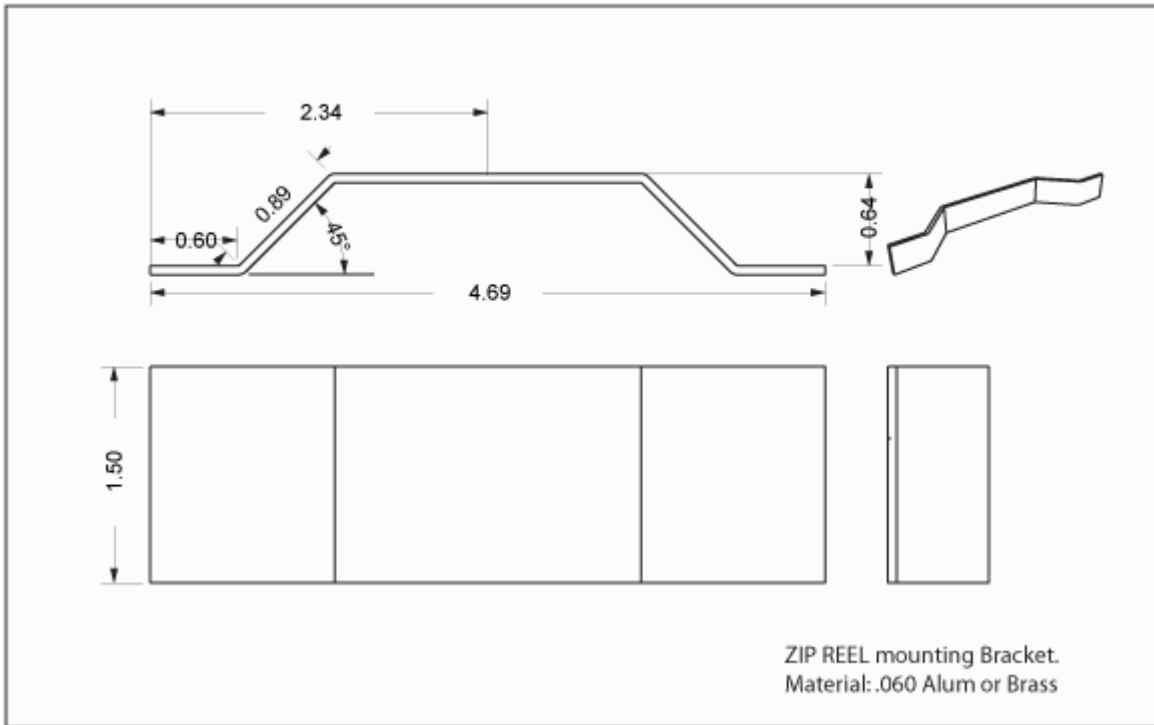
assembly into the valve body. Now you can carefully replace the diaphragm and re-assemble the valve (*below*).



This should have you ready to wind some line on the reel, and go test it. For a weight, I use two 3/4" PVC end-caps with a short piece of 3/4" tube to align them and I use the PVC cement to hold it all together. Most of mine also have a 1 oz fishing 'egg' sinker for additional weight.

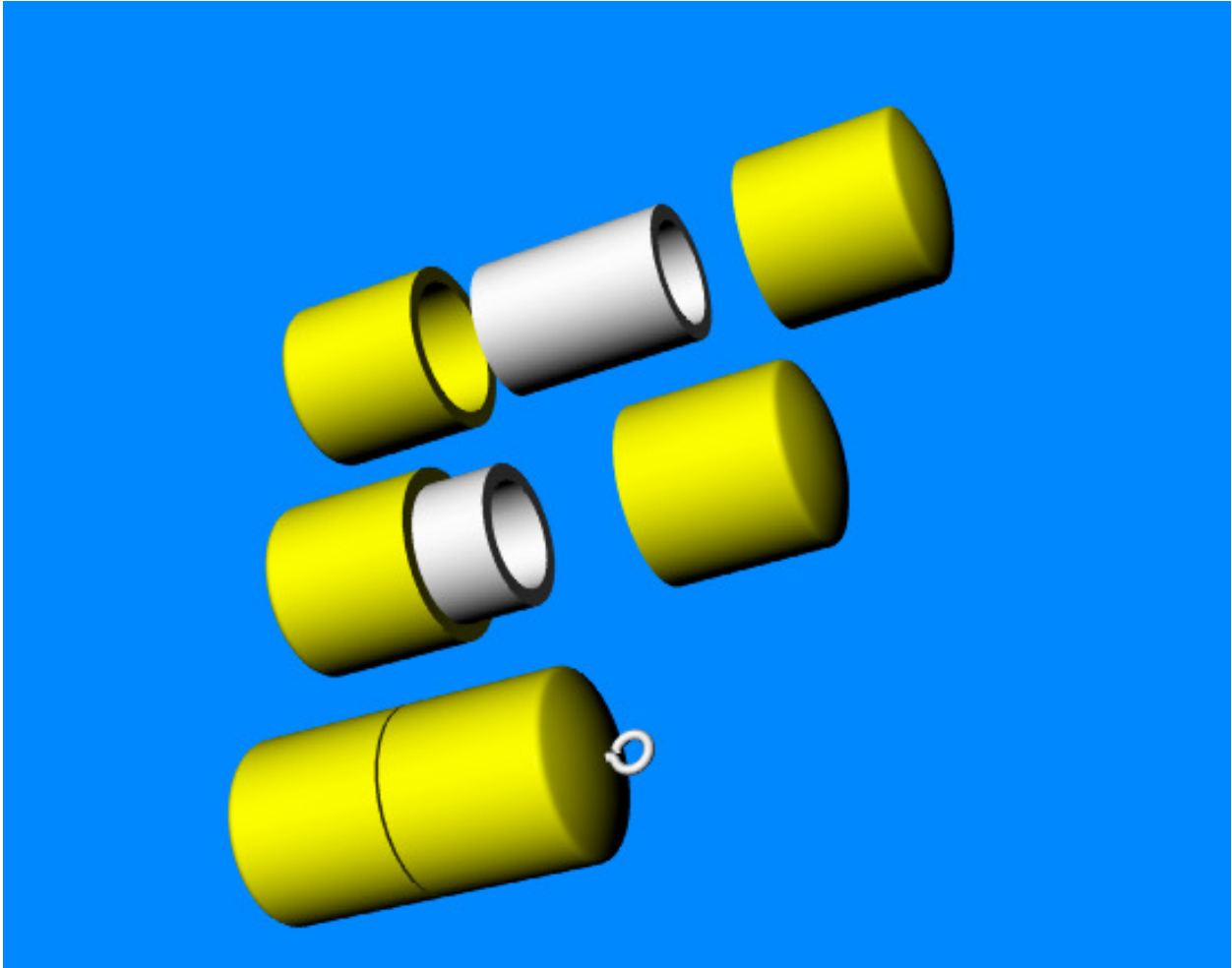
This has been a fun project and one that promises to be a very useful addition to my antenna setup. Let me know if you want to tackle this project, and how you have faired.

I promised a drawing of the ZIP REEL mounting bracket. See below... This is not an actual size drawing, and none of the dimensions are real fussy. It must fit the reel mounting plates, and offset the barrel coupler about 5/8 to 3/4 inch, so that the barrel is near the center of the reel. After I checked everything for fit and alignment, I added a bead of 'Hot melt' glue from one of those cheap Walmart glue guns along the gap where the coupler attaches to the bracket. I don't think the photos show this, but it prevents the reel wobbling on the bracket.



## The String Weight (bullet)

Now for the working part of the whole shebang, the projectile or bullet, or string weight. This is the item which pulls the string from the reel and over the tree. I use two (2) 3/4 inch PVC caps glued together with cement using a short (approx 1 1/2" ) piece of 3/4" PVC pipe. I usually glue the tube to one cap, set it aside to dry and do several at a time. You will lose one or two so it pays to have an extra one with you. While the first section is drying, I also drip in a 1 OZ "egg" sinker from the fishing department to add a little extra weight to pull the line down through the limbs and foliage. Then drill a small hole (1/16) in the center of the remaining cap and cement it onto the first, the tube will align them perfectly. Don't worry if the weight rattles a bit. The hole serves two purposes, one, it lets the air out so the second cap goes on all the way with little effort. And it also provides a starter hole for a small screw-eye to attach the string. I used to tie a loop in the string and loop it through the 'eye' and then over the weight and pull tight. After the shot, slip the weight back through the loop and remove the string and tie the next line to the loop and pull back from the reel to pull up bigger line or the antenna. The next picture shows the three steps in the assembly of the weight.



Also note the that a coat of "Yellow" paint after assembly makes the weight easier to see in the tree or on the ground. Also, I have found it helpful to clean the end of the screw-eye where it butts against the shaft, close it up tight with pliers and apply a small amount of flux and solder this gap closed and make sure the solder makes a nice clean shinny fillet. This keeps small string from escaping and provides a smooth surface free of snags for the string. You can also attach a swivel assembly here to attach the line, may be useful for small line.