A Compressed Air powered Antenna Launcher

Alan K Biocca, WB6ZQZ http//www.qsl.net/wb6zqz/

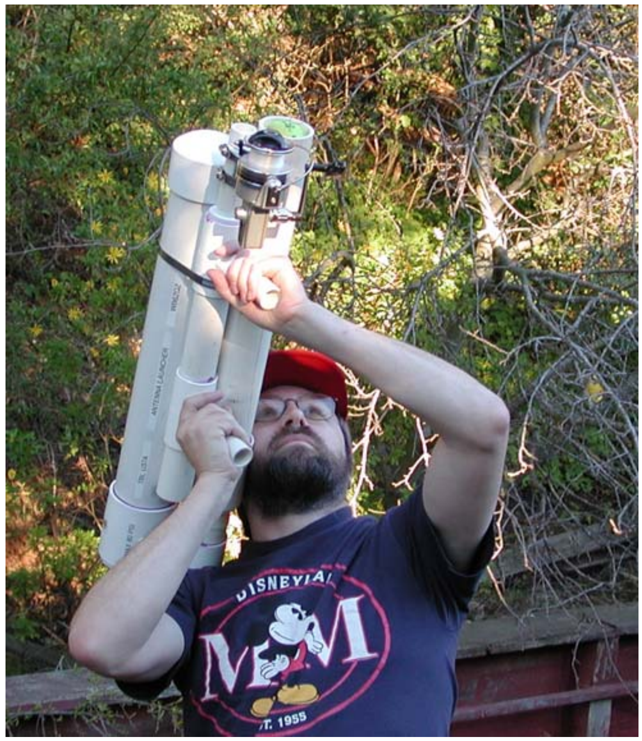
This is the article essentially as it was published in QRP Quarterly Volume 44 Number 2 Spring 2003 page 20. For updated information on this and other Antenna Launchers visit the web URL www.qsl.net/wb6zqz or send email to the author wb6zqz at arrl.net.

In this article I will describe a simple Compressed Air powered Tennis Ball Launcher suitable for putting lines over tall trees to install Antennas. Comparisons to other methods, Safety, Legal issues and Construction are discussed. It should be noted that the author does not warrant components used outside of or within manufacturers' suggestions.

Rapid Deployment Inverted "L" Antenna

I needed an 80 meter antenna for the new Elecraft K2 that my son Chris, KG6LXL and I built together, so during a break in the weather I took the slingshot, fishing weight and reel out into our wooded backyard and proceeded to get the weight stuck in a redwood tree repeatedly. Seems the wet branches (we've had plenty of rain this December) present too much friction to the monofilament line, even with a one ounce sinker. After bouncing the sinker off the roof and gutter three times during the retrieve I decided it was time to escalate. I considered bringing out the archery equipment but decided instead to test out the new prototype Compressed Air Tennis Ball Antenna Launcher...

There wasn't much daylight left, and the wet foliage was clearly "high friction," so I selected my heaviest weighted Tennis Ball, tied it on, pushed it down the bore and carefully arranged the monofilament to the fishing reel mounted next to the muzzle so it would feed properly. I didn't have time for repeat tries, so I put 75 psi in the pressure chamber and proceeded back to the tree. I positioned myself about fifteen feet from the base and aimed at a high angle to clear the tree, but keep the landing close in.



The author aiming high, tennis ball about to emerge from barrel

I pushed the microswitch, and the sound - a 'thunggg' sort of like a cork popping out of a barrel with an echo (my daughter says it sounds like the bark of a walrus) - was followed by the hiss of the line as the ball sailed up and over the tree. It worked, however, the launch exceeded my expectations a bit.

The tennis ball flew in a high arc over the tree, more than fifty feet beyond into the backyard, and over a couple more trees. In total, about a hundred and fifty feet vertically and some eighty feet horizontally. I hadn't

Overall view: note the electric sprinkler valve on the left.

Fishing reel and tennis ball in the barrel.

planned it quite that way, expecting to just overshoot the first tree, but I apparently had set the pressure a bit higher than required. The result was excellent - it did the whole inverted L wire path in one go, and the weighted tennis ball came down on its own with no fuss, so no time was wasted there.

I pulled nylon twine back over the trees to the reel and then towed the 14 gauge insulated stranded wire back up and over, stopping just before it started to come down on the far side. I will have to replace the twine with better cord if this antenna is to stay up more than a few months, but right now, the resulting antenna is approximately 60 feet vertical and 60 feet horizontal. It came out nicely, especially for one launch. I rolled out 150 feet of counterpoise in a “C” shape along the fences and retaining wall below the antenna wire, and fed it with an SGC 239 tuner. EZNEC predicts wonderful patterns from the antenna on 75 meters, and so far the signal reports have been excellent. It also tunes well on 160, though I haven't tried any contacts there. We've had incredible winds since then, and the antenna has stayed firmly in the trees.

Background

About 30 years ago, on one of my early local club Field Day outings, I observed a Field Day tower snap a guy mounting ear as it was lowered. It tossed a couple of hams off the roof of a van and did some minor damage, but miraculously no serious injuries resulted. Watching this near-disaster significantly increased my appreciation for tower safety in field situations.

We started our own Field Day group a few years later. We make an annual trek to the Sierras for the event, choosing different places in the National Forest from which to operate. We've never used (metal) towers, but the forest provides trees up to more than one hundred feet tall which we use for supporting our Beams and Wire antennas. We commonly put dipoles and wire Vee Beams up to a hundred feet, and aluminum triband beams at the fifty to seventy foot mark (supported from above), yet our feet never leave the ground and we don't have to haul and set up towers in the mountains.

To put lines in the trees, we've used many techniques over the years, with archery being the most capable and slingshots the most convenient, each with differing performance envelopes. We've developed improved equipment and techniques, but there are still some issues. The slingshot is the most compact system, and will propel up to about a one ounce sinker to heights of approximately eighty feet. It requires modest strength, and has reasonable accuracy. The

Sprinkler valve, pressure gauge, fill valve.

difficulty is in getting the weight to pull the line down once it has touched the foliage. If the tree is dry, or the branch is dead and dry, it works well. Some of the time (such as Field Day 2002), the weight won't come down.

Archery gear can reach greater heights, completely overshooting trees over one hundred feet tall. For best performance, the arrows should be heavy (I use solid fiberglass fishing type, but with blunt points), and additionally they can be weighted with a stack of washers at the tip (with a machine screw threaded through them and into the standard removable point socket). Pulling the line down on the far side of the tree is still a potential issue, though adding the extra weight generally helps that. It is difficult to modulate the height of the shot, so it often goes farther than desired. The bow requires significant strength and skill, and we have experienced at least one incident in which an errant launch caused minor imperfections in the hood of a fairly new Toyota pickup. Additionally, a few expensive arrows have never come down, at least while we were there.

Prior to Field Day 2002, Eric, WD6CMU, and I were discussing other possibilities. Safety and projectile cost were both high priority requirements, and Tennis Balls seemed to be the best possibility. A bit of research on the Internet turned up some ideas, and Eric built a couple of prototypes. The first one worked, but had inadequate performance, so he optimized all variables and produced a 25 pound four foot long machine I'll refer to as "Big Bertha." This monster had significantly more performance capability than we needed, and Eric used it very successfully on Field Day, 2002, providing lines for nearly all our antennas. There are a few pictures on the ARRL Field Day website (see URL below) as well my large PVC Slingshot. But Bertha stole the show, launching accurately and easily over the hundred foot trees at this year's site, and the three hundred and sixty foot Vee Beam that Mike, WA6ZTY, and Eric erected at ninety feet did an amazing job under Weo, WN6I's callsign on Field Day.

I wrote a computer model of the pneumatic system with some consultation from John Bercovitz who provided suggestions and equations for computing the airflow in the valve, which is supersonically limited during much of the launch cycle. Based on measurements Eric made from Bertha, I calibrated the software model and ran many "computer experiments" with different storage chambers, barrels, valves, and tennis ball weights.

My goal was to develop a Pneumatic Launcher that has adequate performance, is a reasonable size and which is easy to construct from commonly available components at low cost. The launcher described below is the first prototype from that design process.

The TBL-U37A Launcher

This Tennis Ball Antenna Launcher is a simple device consisting of an air storage chamber, valve and barrel. This model uses readily available parts - it should be possible to stop at one or two well-stocked hardware stores and a Radio Shack on the way home from work one day, pick up all the parts

Rear handle with trigger switch

(except the fishing reel and line) for about fifty bucks, and build the system in a few evenings.

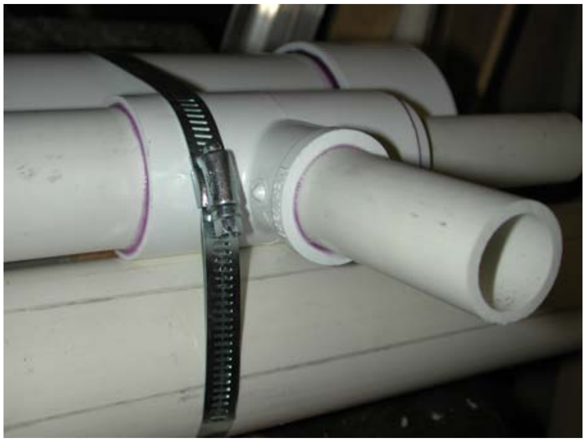
The modelling shows the performance bottleneck is in the valve, so I selected a Rainbird 1" electric sprinkler valve because they are readily available and have about the best flow of this valve type. The pressure storage chamber is a 3" by 24” pipe section, and the bore is a 21" length of 2.5" pipe (in which the tennis ball fits snugly). I used a 4.75" expansion chamber of 2" pipe to make the bore extend beyond the pressure chamber and to avoid having the two large couplers overlap. It would be slightly simpler to make the bore longer, but the computer modelling I did indicates the valve doesn't flow enough air and the ball will start to lose velocity in the longer bore. The overall length is under 37", chosen solely to fit between the wheel wells of my Toyota 4-Runner for convenient transport. If the pressure chamber and barrel are lengthened less pressure will be required to achieve the same performance. More performance is also possible, but probably not useful for our purpose.

Comparisons with other Launching Methods

How do Pneumatic Launchers compare with slingshots and archery gear? My experience is that slingshots generally are good up to seventy or eighty feet of height, and the sinkers I've used (1 oz) simply don't pull the line down well under all conditions. This is generally not sufficient to shoot over the trees we normally encounter, so you have to thread your way through the branches. I haven't tried heavier sinkers, but that would require a bigger slingshot, which I constructed, and heavier bands, which I haven't evaluated. I'm a bit concerned about the big sinker coming down - it is somewhat dangerous - especially when it gets stuck and you have to pull it back!

The Archery gear is great - I use a solid fiberglass fishing arrow and (for best results) weight the tip with a stack of washers (a suggestion from Richard, KO6TI), and a 55 pound compound bow with a large spinning reel mounted. It is a bit of a production to use, and requires quite a bit of skill and strength. It is also difficult to regulate the height of the shot. The weighted arrows coming down are dangerous as well, and are expensive to lose when caught in a tree. The bow setup is large, fragile and fairly bulky to take to field. The equipment is also somewhat expensive, and very few are willing to procure it just for this one purpose - most antenna archers use equipment they already happen to have. In our group, this makes launching all the Field Day lines fall to just a couple of people.

The Pneumatic Launcher provides a high degree of accuracy, and very controllable velocity (height) by varying the pressure. It launches a very low cost projectile that is inherently less dangerous than a lead sinker or an arrow. The ball can be made heavy enough to pull the line down - this saves a great deal of time in the field. In my experience the time spent fiddling with the weight/arrow/line getting it to come down often exceeds everything else, so the total system time may end up being less with the Pneu-



Front handle and main clamp.

Inside the trigger switch handle.

matic. Finally, the Pneumatic Launcher offers significantly more performance than either the slingshot or bow. It does not require as much strength or skill to operate, though one must be strong enough to hold it when launching, as the model described here weighs about ten pounds. The pneumatic launcher is somewhat slower to deploy for a launch than the slingshot or bow, but the increased performance and higher success rate may more than compensate. Due to the low cost and ease of use it is also possible to have several launchers available so these activities may be occurring in parallel, and augmenting the slingshot (and possibly the bow) with the pneumatic works out well - use the slingshot where it reaches, and the archery or pneumatic for the tougher paths. The additional performance may be useful to reduce the required time in some cases, as when launching an inverted L antenna in one shot as described in the example above, instead of the two it would usually take (one for each support point).

Construction Information

1. Cutting

I use a 10" radial arm saw with a carbide-tipped blade to cut the pipe, but a hacksaw works fine. Cut it square and clean up the ends with the file and/or sandpaper. The lengths I used are shown in the parts list. Be careful when prefitting the parts, if they are put together tightly they may not be separable.

Don't cut the main handle 1.5" PVC pipe section until later, this part should be fitted for best results.

2. Gluing

Read and follow the instructions on the PVC solvent cement very carefully. There is a lot of force on these joints, so proper cleaning and gluing are very important.

The cement I used is a two-part process starting with a purple primer, followed by a clear cement. Newspaper and gloves are useful to minimize the mess. Look carefully at the photos and ensure that the few joints that are not to be glued are not done by accident.

Glue the barrel first (7 parts) and then the pressure chamber (5 parts). Glue the reel adapter ring and the front handle into the front handle tee (3 parts). The main handle needs to be fitted and will be glued later - do not glue it now.

Don't glue the rear handle until the electrical system is installed later, and don't glue the reel mount or the rear battery cover at all. Let the cement cure at least 24 hours

Electrical wiring and batteries

Tennis balls, tools and weights.

before handling.

After the cement has cured, thread the barrel on the output of the valve (there is a flow direction arrow), and the pressure chamber on the input. I use two to three wraps of teflon joint tape on the threads to improve the seal. Turn them until they are fairly snug, but don't go so far as to crack the Valve or PVC. Locate the Filling Valve and Pressure Gauge on the pressure chamber. They should be drilled through the coupler so there is a double thickness of PVC to thread into, but avoid drilling too far to the rear where the adapter stack is solid. Refer to the photos to see where to locate them. Drill and tap them. Avoid running the tap too deep - this is a tapered tap and running it too deep will prevent the valve and gauge from sealing. Before installing them remove the pressure chamber from the valve and clean out the PVC dust from inside as this could make the sprinkler valve diaphragm leak. Reassemble and install the fill valve and pressure gauge.

3. Sizing the Separator Block

A small wood block is used to maintain the separation between the pressure chamber and barrel tubes. The goal is to keep the pressure chamber and barrel tubes parallel. The U-valve determines the spacing at one end, and the wood block does so at the other. The handle tube and the opposing sight tube should not quite touch the block, but the pressure chamber and barrel should sit firmly on it. I used a slice from the end of a two by four, one half inch thick. The large hose clamp is used around the whole assembly to hold it together. Tighten the hose clamp enough to hold everything, but not so tight as to distort or crack any of the PVC tubes.

4. Proof Testing

The maximum operating pressure for this system is determined by the weakest component. This is generally the electric valve, as the 3" schedule 40 PVC pipes and fittings have ratings of 260 psi (and the smaller pipes have higher ratings). The Rainbird valve I used is rated for a maximum operating pressure of 150 psi. I recommend choosing a maximum operating pressure well under the valve maximum pressure. I use 80 psi as a maximum operating pressure. High pressures will only marginally improve performance as the valve is limiting the flow during the time the ball is in the bore. If more performance is required construct a longer pressure chamber and barrel.

The proof test pressure should be slightly higher than the operating pressure, I use about 25%. For an operating pressure of

80 psi the proof test pressure would be 100 psi. The proof pressure must also be under the lowest maximum safe pressure of any of the components, which in this case is the 150 psi sprinkler valve.

After the cement has cured at least the minimum time, it is prudent to Proof Test the launcher. To do this, wrap it in a heavy old blanket, wear eye protection and gloves and pressurize it to the proof test pressure and leave it for 24 hours or more. If the pressure drops more than 5 psi, refill it to keep the strain on. If it drops too quickly, find and fix the leak(s) and re-test. When the test is complete relieve the pressure through the fill valve. The proof test should be repeated periodically such as annually before Field Day, and preceded by a careful inspection looking for any incipient problems.

5. Preparing the Rear Handle Tee

I installed the trigger switch into a small hole in the rear handle reducing Tee. The threads were not long enough to use the standard nut, so I used Epoxy to glue it in place. The switch will be glued in later, but the hole must be drilled now before the Tee is glued into the central handle tube. The switch should be convenient to depress intentionally while difficult to actuate accidentally. I placed mine fairly high to reduce the danger of unintentional triggering.

6. Handle Assembly

The handle assembly is constrained longitudinally by the pressure chamber end cap and the barrel coupler. The forward tee/handle has the reel mount, and the rear tee has the trigger switch (just a hole now). Trial-fit these tees on the assembled barrel/valve/pressure chamber. Slide the forward handle forward until it contacts the Pressure Chamber Cap, and slide the rear handle rearward until it contacts the Barrel Coupler. There should be approximately 6" between them. Measure this distance. Add 2.75 inches to this (the depth of the two slip glue sockets). Cut the main handle from 1.5" PVC a shade under this sum length so the completed part will fit without too much play. Glue the two tees to this main handle tube and make sure it fits between the couplers against the barrel.

7. Electrical Wiring

The electrical system is very simple - the two battery holders, the switch, and the valve solenoid are wired in series. The only polarity concern is the battery connection, as the batteries must be series aiding to produce 24 volts to operate the U-valve reliably. Leave enough lead length to be able to slide the battery holders out for service. Solder and tape the joints, except the joints on the wires to the solenoid must be removable, so use wirenuts there. (If you want to get fancy a connector could be used here instead of wirenuts.) Install the batteries and test. The Solenoid should make a quiet but positive thunk when the switch is depressed. Install the switch into the hole prepared earlier in the rear handle tube. I used Epoxy for this. Take care to keep glue out of the switch. After testing, the rear handle 1" PVC tube can be glued into the Tee. Take care to avoid getting glue into the switch.

8. Fishing Reel Mounting

I used a Daiwa 4000C ocean spinning reel that I had lying around, but any large to medium reel should work. Some folks prefer closed face casting to spinning reels, which is fine. The main requirement is to hold enough line heavy enough, and feed it quickly enough without catching or excessive friction, so the larger reels are best. Avoid bait casting type reels - the spinning spool will overrun and backlash terribly!

The reel is mounted to a 5" piece of 1" PVC pipe inserted in the front of the handles, and this pipe is removable (not glued) so the reel can be operated without holding the entire launcher. The reel is located right at the end of the bore, and the small stainless steel hose clamps are used to mount the reel to the PVC. It is very important to avoid snags, so be sure to position the clamps away from the top front where the line will be whipping about. I often cover the clamps with electrical tape to reduce snagging.

9. Tennis Ball Preparation

I used a leather (Speedy Stitcher (R)) sewing awl to put a loop of tough dacron in the tennis ball for fastening the line to. After tying a couple of good square knots I pulled them around to be inside the tennis ball to protect them from abrasion in the bore. We have not lost one of these yet, but it is a real timesaver to prepare a few tennis balls in advance.

A standard tennis ball weighs 2 ounces, and this is not always enough weight to pull the line down against the friction presented by the tree branches. The weighted balls have two advantages. One is the improvement in pulling the line down. The other is a slightly slower trajectory for the same height, which can help with line breakage if that is a problem.

You should always use as little additional weight as necessary for safety reasons. I have added up to 6 oz of lead shot by slitting the ball and working a small plastic bag holding the lead inside the ball. Although I haven't tried it, sand should also work, though the ball will fill up at a lower weight. Experiment.

My plan is to have several different ball weights, and use the lightest that will accomplish the objective. Two, four, and eight ounce balls will be in my kit next Field Day. Perhaps a four ounce ball (with two ounces of added weight) will be about optimal, but only more field testing will tell.

System Calibration

I have measured performance data on this model with a chronograph (measures velocity). The following table shows approximate trajectory peak height in feet for launch pressures from 50 to 80 pounds per square inch, and even ball weights of 2 to 8 ounces. It was determined by measuring the velocity and computing the height based on a simple drag model. There are many sources of variation, so this is not precise.

Peak Height in Feet

Pressure	Ball weight (oz)			
(psi)	2	4	6	8
50	40	80	80	70
60	80	160	120	110
70	140	200	160	150
80	190	230	190	180

The Launcher can be pressurized with any air pump capable of the pressure - the electric 12vdc automotive tire pumps are excellent, and a hand or foot pump works also. This design requires about 40 psi to start working, and the useful pressure range is from about 50 to 80 psi.

The first time out, characterize the pressure performance of the system. Start at 30 psi and go up in 10 pound increments. Launch in a clear area next to some trees to help gauge the height. The ball won't bounce much if you cut a slice in it to relieve the pressure. Don't use more pressure than needed to achieve the desired objective, and don't exceed the planned operating pressure. The line paid out during the launch can be measured to determine accurately the height of the launch.

A version of the Modeling software I developed for Pneumatic Launchers is available on my website (link below). This model computes velocity and height for various pressures given physical data about the system such as volumes, bore length and system flow capacity. If you have access to a chronograph a measurement of the velocity can be used to calibrate the system flow coefficient. Detailed velocity and height tables can be prepared for different ball weights. See the website for further details.

Using the Antenna Launching System

1. Preparing for Launch - Choosing the Path and Landing Area

The most successful launches are usually those that are well planned. Consider which direction(s) are available to launch in. In some cases the safety of the landing area determines the direction of the launch. Other issues to consider include which direction the line needs to go, and how much room there is for the landing. I usually plan my launches to pull monofilament over, then nylon twine back, and last either the wire antenna, or a heavier line to support a beam or longer wire. The plan followed above, launch over several trees, pull twine back, pull wire antenna up into inverted L, is one of the quickest and easiest to execute in one launch. Make certain the landing area is clear and safe, and that an overshoot will also be safe - these things have a way of going further than planned, especially if the line breaks.

2. Choosing ball weight

The 2oz balls fly fast and high, and are the safest, but the friction may make recovery on the far side of the tree difficult - if the ball won't pull the line down. The 4oz models fly about 30% slower for the same height, and come down a bit harder. Balls heavier than 4oz don't go as high (4oz is about optimal) and land increasingly hard. Use a ball heavy enough to pull the line down, but no more.

3. Loading

The reel should be positioned slightly beyond the muzzle of the bore. The reel oscillates as the line is reeled in to spread the coils, so position it to the most forward position for optimal clearance. Tie a large loop into the end of the line, large enough to slip the tennis ball through. Slip the line loop through the ball loop, and then around the ball. Push the ball into the bore until flush with the muzzle, just to hold it while setting up the reel. Set the drag on the reel to near zero, just a slight tension on the line. Take up any slack by rotating the reel spool by hand. Push the ball all the way in - the reel should feed out line as it goes. Open the bail. Make sure this step is not skipped.

4. Pressurizing

Keep the muzzle pointed in a safe direction. Refer to the chart to select the desired pressure. Be very careful if using an electric compressor - don't get distracted and let the pressure climb too high! Eric, WD6CMU uses a Gel Battery (such as a 12V 7AH) and portable 12 volt automotive type compressor, so he can carry it in the field to right where he is launching - very convenient!

5. Observers

It helps to have one or two observers who can watch the trajectory of the ball, especially in the landing area. They should be positioned in a safe place such as off to the sides of the intended path. Safety glasses and hard hats are recommended.

6. Safety

Eye protection should be worn for safety. Point the muzzle in a safe direction at all times (up, downrange).

Perform the Final Check. Check the open bail and line position. Check the pressure. Look downrange and insure it is clear. Check that the observers are ready. Let them know you are about to launch.

Take aim. Hold the launcher firmly - there is modest recoil, especially with the weighted balls, and follow-through - it takes a noticeable time for the ball to eject. If you don't follow-through you may miss your spot. Countdown and Launch. Everyone should know when it is launching, and should keep a watch in case the ball bounces off the tree in an unplanned direction.

Once the line is over the tree(s), locate the end and remove the tennis ball from the end. Tie the end of a roll of nylon construction twine to the monofilament and reel it back over the tree(s). If a heavier line is needed, pull it with the twine, but for short-term wires the twine can be used to support (most) wires directly.

7. Problems

Occasionally there are problems with line breakage. Generally this is caused by forgetting to release the reel, or the line snagging on something. Using a shock absorbing leader or a few feet of much stronger line for the leader may help, though we have not resorted to that yet. One thing to consider is where the line will part if it gets stuck and you have to break it off. It is probably desirable to have it break near the ball rather than down in the middle of the line somewhere. Usually the knot near the ball in the monofilament will break first.

Wind causes a couple of problems. It doesn't affect the weighted ball too much, but the line gets blown around. You can sometimes take advantage of it, while at other times it can drift the line away from the tree before it drops into place.

Variations and Improvements

Pressure safety valves are available that will release the pressure if it reaches an unsafe level. This would be a good safety improvement, especially if an electric compressor is used to fill the chamber. Be sure to select a pressure relief valve which is large enough to handle all of the compressor's flow.

The barrel and chamber length are approximately the minimum for adequate performance for Antenna Launching. Making these longer will increase performance, or allow the same performance at lower pressure, which provides increased safety.

The trigger in this prototype unit does not have a trigger guard or a safety switch. Both of these items would be a good improvement. A mercury switch could be installed in series that would only allow launching upward. A second pushbutton in series would require both to be pushed to launch, keeping that free hand out of danger.

Pneumatic Triggering opens the valve faster, and increases the flow into the bore. It replaces the batteries, switch and solenoid with a hose and manual valve. Eric's design works this way. Details can be found on the internet.

Shielding the pressure chamber to contain possible PVC shrapnel in the case of a failure might be a worthwhile safety improvement. Tape, cloth, Mylar, nylon or wire mesh, etc. might be employed.

Safety and Legal issues

There are several Safety and Legal issues that need to be considered in this project. There is considerable energy stored in the compressed air; it is important that it not be released in an unintended manner. Read the preparation, gluing, and curing instructions carefully and FOLLOW THEM. Use only NEW PVC and CEMENT, and don't use any material which is obviously yellowed, scraped, cracked, or weathered. Proof testing is prudent, and repeating it periodically is a good idea. If the unit is ever subjected to dropping, severe shock, extended sunlight, chemicals or other conditions known or suspected to be damaging to PVC, or any flaws in the material become visible, then immediately REPLACE the questionable components.

WARNING - while the schedule 40 PVC pipe I used is rated at 260 psi or better operating pressure, the manufacturers DO NOT RECOMMEND it for use with compressed air (remember, this is water pipe). If it fractures under pressure PVC SHRAPNEL may result. It may fracture if dropped or hit by a hard object. If you choose to build one of these you must take responsibility for safety.

Legal issues are another matter. The U.S. Government BATF (Bureau of Alcohol, Tobacco, and Firearms) has ruled that compressed air launchers are not firearms, and so they are not regulated by firearms law. Pneumatic launchers are used commercially for many purposes, including launching T-shirts at games, explosive charges for avalanche control and they are common high school science projects. Remember, the velocity of this launcher is similar to velocities achieved on a tennis court with a tennis racket, but the weighted balls have considerably more momentum.

There are other types of launchers that use fuel combustion (such as lighter fluid, propane or hairspray), and they are often used to shoot vegetables (potatoes, apples, etc). The combustion systems are less predictable and not as safe or well suited to line launching for antenna installation.

Local municipalities may also have rules about the use of some types of these systems, so do some research. Whatever you choose to do, make sure you do it in a safe and responsible manner. Always wear eye protection, use the minimum ball weight, minimum chamber pressure, and insure that the area is clear before launching...and NEVER point the launcher at any person.

It is best to do initial testing in a wide-open space to learn the performance parameters. We primarily deploy them in National Forest lands where there is plenty of room. Work pressures up gradually to avoid being surprised.

NOTE: that other launching systems are generally more regulated - Archery and Slingshots are illegal to use in many or most municipalities, for example.

Neither the Magazine nor the Author is responsible for any injury or damage resulting from anything you choose to do. You are wholly responsible for safety and legality.

Future Plans

I am working on a couple of different new designs for Antenna Launchers. The goal is to reduce the size and weight of the system even further. Unfortunately this seems to require using more exotic parts that are both harder to obtain and more expensive. The design described in this article represents a good balance of performance, size, weight, cost and availability of components. It is very effective, and also a lot of fun. Refer to my website (burl listed below) for updated information. Safe Launching!

Thanks to John Bercovitz, Eric Williams WD6CMU, Dawn Biocca KB6LHP for help in preparing this article. Photos by the author and Dawn KB6LHP.

Appendixes

Parts List for the TBL-U37A

- Electric sprinkler U valve, 1" fpt (female threaded), 24V, Rainbird model DAS/ ASVF-100—There is another Rainbird model that has a piston valve instead of the diaphragm valve in this model. The performance of the piston valve has not been tested by the author.
- 1" diameter by 1.5" 'short' threaded pipe, brass or iron, 2 each all pipe threads in this project are NPT (National Pipe Thread) tapered 1" or 1/8"

NOTE: ALL PVC Pipe and Fittings must be PRESSURE RATED SCHEDULE 40!!! Schedule 40 is ALWAYS MARKED as such. Accept no substitutes and DO NOT use anything but schedule 40 pipe! This is a SAFETY issue.

- 1.5" slip x 1" fpt (female threaded) PVC adapter bushings, 2 each
- 3" slip to 1.5" slip PVC adapter bushing
- 3" slip-slip PVC coupler
- 3" by 24" long schedule 40 PVC pipe long (main pressure chamber)
- 3" slip PVC end cap
- 2" slip to 1.5" slip PVC adapter bushing
- 2" by 4.75" long schedule 40 PVC pipe (expansion chamber)
- 2.5" slip to 2" slip PVC adapter bushing
- 2.5" slip to slip PVC coupler
- 2.5" by 21" long schedule 40 PVC (barrel)
- 1.5" slip x 1.5" slip x 1" slip PVC reducing Tees, 2 each (1" port on the side)
- 1.5" slip x 1" slip PVC adapter bushing (reel mount adapter)
- 1.5" by 25" long schedule 40 PVC pipe, cut to:
- 10" sight tube
- approx 8-9" main handle center tube and battery compartment (fitted)
- 4" rear battery cover
- 1" by 15" long schedule 40 PVC pipe, cut to:
- 6" reel mount
- 4" handles, 2 each
- 3/4" by 24" long schedule 40 PVC pipe (ramrod)
- FRESH PVC Primer and Glue with applicators (small 2oz cans adequate)

- Schrader Valve, 1/8" NPT thread (fill valve)
- Pressure Gauge, 160 psi, 1/8" NPT (chamber pressure)
- Two each 8-AA battery holders, approx 1" by 1" by 7", Radio shack model 270-407A
- Two each 9v battery connectors, Radio Shack model 270-324
- Small momentary pushbutton switch rated 0.5A 30VDC or better, such as
- Radio Shack 275-1547 or 275-1549 or similar (trigger)
- Two medium wirenuts
- 12" tie wrap
- 16 gauge wire, approx 24"
- 4+1/8-7" diameter hose clamp, stainless steel (main clamp)
- 1+1/16-2" diameter hose clamp, stainless steel, 2 each (reel holders)
- Small block of wood, approximately 0.5" by 1.5" by 3.5" (separator block)(fitted)
- Fishing Reel, large spinning or closed face casting type, with 200+ yards 15-20 pound monofilament line
- Tennis Balls, 3+
- Lead Shot or Sand to add weight, up to 6 oz each (optional)
- Plastic Bags, sandwich type, to hold shot/ sand (optional)
- Misc - Epoxy, Electrical Tape, Teflon Plumbing Tape, Solder, heavy thread, 16 each AA batteries
- Tools - Saw, File, Sandpaper, Drill & bits, small soldering iron, 1/8 NPT tap, heavy needle, utility knife, Latex gloves

Related Web Links

ARRL Field Day 2002 WN6I photos including Big Bertha Launcher and Big Slingshot:
http://www.arrl.org/contests/soapbox/index.html?con_id=13&call=wn6i
(or go to the ARRL 2002 Field Day website and search for WN6I)

Rainbird Valve:
http://www.rainbird.com/pdf/diy/DAS_ASVF.pdf
http://www.rainbird.com/diy/products/valves/das_asvf.htm

PVC fitting supplier:
http://www.plumbingwarehouse.com/pvc.html

Component supplier:
McMaster-Carr
http://www.mcmaster.com/

Eric WD6CMU's web (home of Big Bertha):
http://www.qsl.net/wd6cmu/

A commercial site with similar devices, and a source for components:
http://www.spudtech.com/

Author's website - modelling software, updates:
http://www.qsl.net/wb6zqz/