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Feature Article

Build A Low Cost Vacuum Chamber

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Build An Easy And Inexpensive Vacuum Chamber

By Mike Momenee

Ok, a show of hands- how many of you actually vacuum-test your altimeter before you first fly it? I see a few hands raised way in the back, but most of you apparently don't. I'm with the majority of you; until recently, I also assumed that my Perfectflite or my other altimeters would work, so I put it them the rocket and hoped.

I've also taken it on faith that the e-matches I've used for dual deployment will be ignited by the altimeter. I've checked them with a multi-tester to verify continuity, but it's more comforting to actually see a representative e-match ignite via the actual altimeter to be used.

A couple of things got me really thinking about testing altimeters in a vacuum chamber (and no- not because of a lawn dart flight). One was the recent series of Apogee Components videos entitled *"Dual Deployment in Rocketry"* (www.ApogeeRockets.com/Rocketry_Videos/Rocketry_Video_26.asp). Part 3 showed a slick vacuum chamber and actual bench tests of two altimeters under vacuum. The vacuum chamber looked really cool, and I started wondering where I could purchase one.

The other thing that got me interested was because of a main parachute deployment device I've built. It activates by the "main" event firing of the altimeter. Although I've ground-tested the device with a 9V battery and a switch, it isn't the same as true testing using the altimeter's firing current of 5A for 0.5 seconds. So I thought about buying a vacuum chamber.

There are chambers out there for the hobbyist, but they are much more than I planned to spend. Actually, I really didn't want to spend more than a couple of dollars, so that left me with the option of building my own. I really didn't find any plans on the internet that interested me, so I stepped back and thought about how would someone build a vacuum chamber with inexpensive, easily obtainable parts? The following is my simple solution.

To be clear: technically, this isn't really a true vacuum chamber. It won't pull a complete vacuum. But for altimeter testing purposes, all one really needs to do is reduce the pressure enough that the altimeter thinks it's at altitude. So a more fitting name probably should be a pressure reduction chamber. But for the purposes of this article, I refer to it as the more easily identifiable term, vacuum chamber.

First, what would I use for the vacuum chamber itself? My immediate thought was of a large clear plastic container with a screw-on lid. At Wal-Mart I found Rubbermaid's 1 Gallon/ 3.8L Square Canister for about $2.50. It is about 10 inches high x 5 1/2 inches wide x 5 inches deep, with a 4 1/2 inch diameter plastic screw-on lid. It's bigger than necessary, but its size allows the complete altimeter sled to be inserted into chamber, instead of removing the altimeter from the sled.

Note the misprint on the label: 3,8L. As a former English teacher, I believe there should be a period separating the numbers instead of a comma. Maybe that's what drew me to this as the container to use for the vacuum chamber? {*Editor's Note: The comma separating the numbers is the European convention for writing decimals, which probably means this container is also available in other countries too.*}

Figure 1: The 1-gallon storage container used as the vacuum chamber.

At this point, I also want to make clear that I'm not trying to make my vacuum chamber airtight. As a matter of fact, I purposely friction-fit everything, just to see if (and how well) it would perform. The screw top lid certainly isn't airtight. But as you read further, you may wish to add simple steps like putting O-ring grease on the canister rim

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to make it more airtight, using Goop or a similar product to seal the friction-fit connections to be described further in to this article, etc.

The next item on the list was some sort of hose to connect the chamber to the vacuum pump (we'll get to the pump in a minute). Ace Hardware sells clear vinyl tubing, 1/4 inch outside diameter, for 21 cents per foot. Buy one yard or two yards- this part won't break the bank, either.

The vacuum pump was a challenge. I didn't want to spend the money on any kind of an electrical pump, like those used for inflating air mattresses. I believe that they can be alternately connected so that they also evacuate air, but I was trying to think of a manual method of reducing the pressure in the chamber.

Something like a bicycle hand pump came to mind- the kind that attaches to the frame of the bike. However, the one-way valve on the air intake would have to be disabled. A syringe would be perfect, but its volume is way too small (100cc is the largest I could find; used for hand-feeding small animals). I thought about how to make something similar, and two methods seemed doable.

The first was to use some rocketry parts I had lying around: a 15 inch long piece of 2.56 inch diameter body tube, a 2 1/2 inch long coupler for that sized tube, a wooden bulkhead for the body tube, and two coupler-sized wooden bulkheads. In addition, I'd need a piece of dowel; the diameter was unimportant. Figure 2 is a photo of the end result, with the two pieces separated to show each.

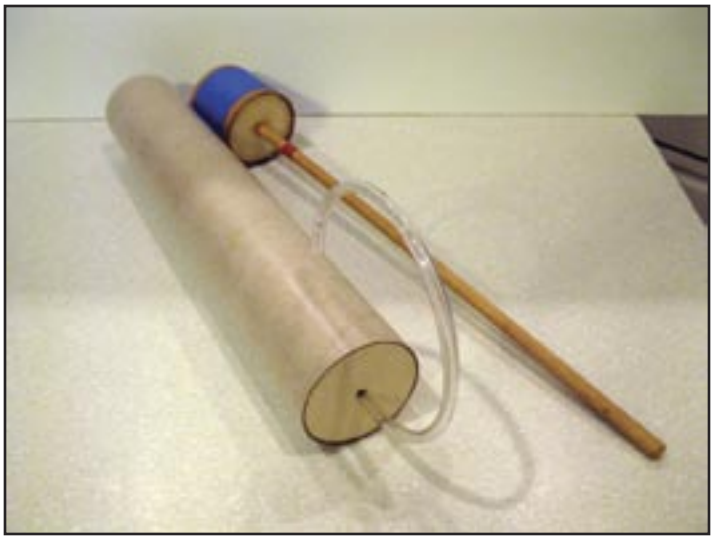

Figure 2: A simple hand pump made from a common rocket parts that can actually pull a vacuum

Using some math, I found the volume that this pump would displace would be approximately one liter (pi times radius of the body tube squared, times the 15" body tube length minus the 2 1/2" length of the coupler (12 1/2"), then using the conversion factor from cubic inches to liters). I assumed that displacing more than 25 percent of the container's capacity, even with nothing sealed airtight, would be good enough to trigger the altimeter's "drogue" and "main" events.

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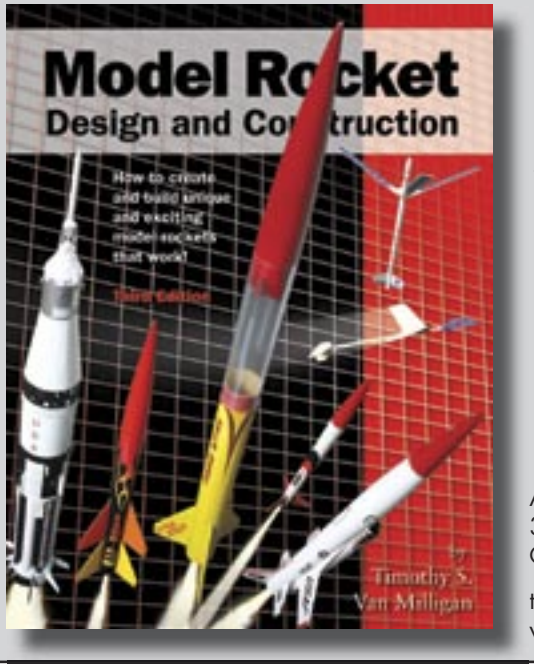

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The construction was straight-forwar. I first drilled a 1/4" hole in the body tube bulkhead, and epoxied it into one end of the body tube. I then determined the diameter of the scrap piece of dowel I had (make sure the length of the dowel is at least a couple of inches longer than the body tube length), and drilled a hole of that diameter into each of the two coupler bulkheads. I slid the coupler bulkheads on the dowel, positioned the bulkheads on either end of the coupler with a 1/16" recess to accept an epoxy fillet, and glued everything on the coupler/ dowel assembly into place. Don't forget to epoxy where the dowel joins each of the coupler bulkheads.

When the epoxy has cured, wrap some masking or blue painters tape around the coupler so that the fit inside the body tube is reasonably tight. But make sure you can, without too much difficulty, use the dowel to move the piston you've created down and back in the body tube. I also put a small piece of red tape on the dowel about 1" from that end of the piston, so that I'll know I'm getting close to the end as I'm pulling the dowel out to evacuate the air from the vacuum chamber.

Drill a 1/4" hole in the center of the container top, cut a one foot section of 1/4" vinyl tube (or longer if you'd like), friction-fit the ends of the tube into the body tube bulkhead hole and the container top hole, and the assembly should look like the photo shown in Figure 3.

Note that the dowel/ piston assembly is fully pushed into the body tube until it touches the body tube bulkhead. It is now in the "ready" position.

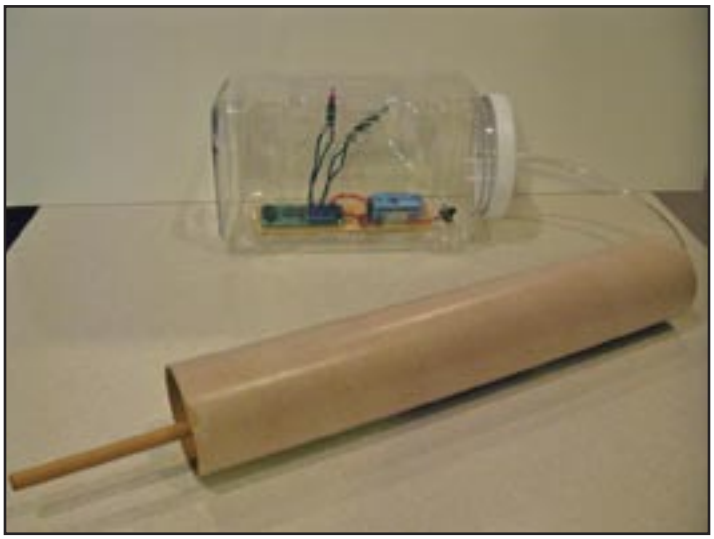

Figure 3: The simple cardboard vacuum piston hooked up to the test chamber.

An alternate method to make a manual vacuum pump is similar, but using PVC parts. I noticed that the inside diameter of a 2 1/2" PVC Schedule 40 pipe (the thick-wall kind) was less than 1/10" larger than the outside diameter of a 2" PVC Schedule 40 pipe. With a little duct tape on the smaller pipe, a tight-fitting piston can be made. It costs about $16.00 to buy sections of the two pipes and a 2 1/2" friction fit cap. That's a lot more than the "free" rocket parts I had sitting around, but if you're into PVC construction....

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I cut the 2 1/2" pipe to a 14 inch length, and the 2" pipe to a 20 inch length. Sand down the burrs that the cutting created so that the pipes will move freely. Seal one end of the 2" pipe securely with duct tape, stand it on end with the duct tape end on a hard surface, and pour about one ounce of mixed epoxy down the tube so that it will pool at the bottom. I happened to have some two-part foaming epoxy, so I used that. Protect the floor under the tube, in case the epoxy leaks around the duct tape.

When the epoxy has cured, remove the duct tape, and you have the piston part of the assembly created. The sealed end will go into the 2 1/2" pipe. But first, wrap some duct tape around the circumference of the 2" pipe at the end where you've sealed it closed with epoxy. I sprayed some silicone spray into the 2 1/2" tube to cut down on any static electricity the two PVC pipes could create (static electricity and altimeters- bad!). Keep adding duct tape until you have a fairly tight fit, but the smaller pipe still moves without binding inside the larger pipe.

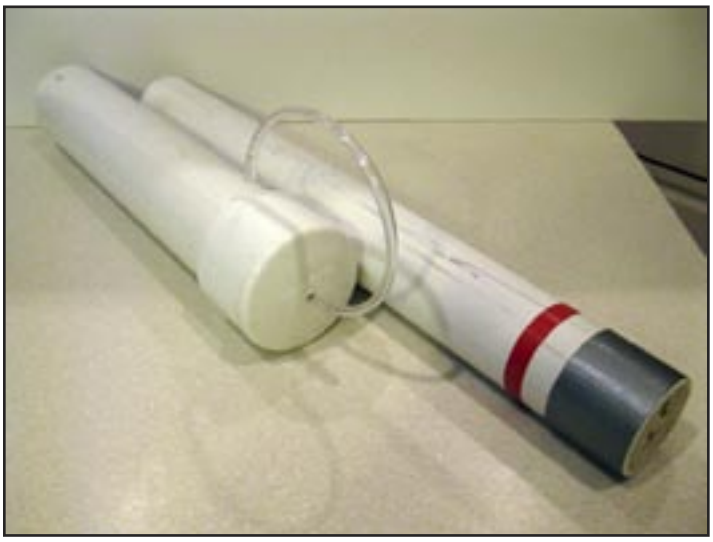

Figure 4: Vacuum piston made from PVC pipe.

Drill a 1/4" hole through the center of the 2 1/2" friction fit cap, cut a one foot section of 1/4" clear vinyl tubing, and friction-fit it into the hole in the 2 1/2" cap. The assembly parts should look like what is shown in Figure 4.

Now load the duct tape end of the 2" pipe into the 2 1/2" pipe, push it all the way down to the friction-fit cap end to put it in the "ready" position, connect the other end of the clear vinyl tube to the vacuum chamber, and it should look like Figure 5.

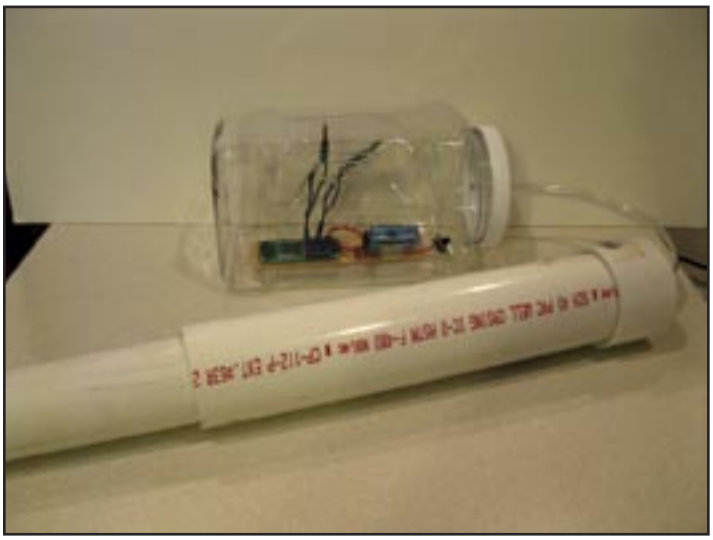

Figure 5: The PVC vacuum piston hooked up to the test chamber.

Using Your Vacuum Chamber

Whichever manual vacuum pump you've built, using the vacuum chamber couldn't be easier:

- Dig out your Christmas decorations and sacrifice a string of minilights. Cut two light assemblies from the string and strip the two ends of the wires of each assembly so

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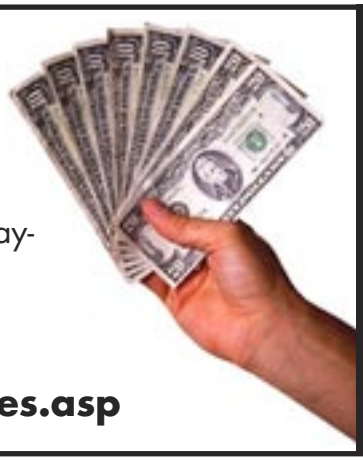

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that they will fit into the "drogue" and "main" screw terminals on the altimeter. Connect them into the altimeter.

- Turn on the altimeter. I used a spare mini switch I had, with wires soldered onto it, to connect to the "switch" screw terminals on the altimeter.

- Let the altimeter cycle through its diagnostics as you screw on the vacuum chamber top. The vinyl tubing is connected between the top of the vacuum chamber and the manual vacuum pump.

- When the altimeter constantly beeps the three chirps that signals that both the "main and "drogue" circuits are connected (for Perfectflite altimeters, and many others), ***pull quickly back on the piston assembly until you see the red tape signaling the end of the piston assembly.*** The altimeter's beeping will stop.

- Because the vacuum chamber isn't sealed perfectly (not even close!), you don't even have to push the piston assembly back in to simulate the rocket's descent after apogee. The air infiltration through the friction-fit parts will increase the pressure, triggering the "drogue" and then the "main" events. The Christmas minilights will illuminate for a split second, as evidence of each event. The photos in Figures 6 and 7 are screen captures from a video I shot, which show the individual lights illuminated. Not hard to accomplish with a camcorder that shoots at 60 frames a second.

Figure 6: The first light indicates the altimeter sensed apogee.

Figure 7: The second light indicates that the main chute's circuit is being fired.

The altimeter will now chirp out the "altitude" which the vacuum chamber simulated. For the PVC pump, the highest altitude pulled was 1,387 feet. For the rocket parts pump, the top altitude was 1,151 feet. For me, those simulated altitudes are high enough to check out the functionality of the "main" event setting, which for me is anywhere from 400 to 1,000 feet. If you want to go higher

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in simulation, simply make your manual vacuum pumps longer, or larger in diameter, or both.

Other "Stuff" You Can Do With Your Vacuum Chamber

I mentioned testing a representative e-match at the beginning of this article. You can:

- Cut another 1/4" hole in the plastic screw top of the vacuum chamber.
- Cut about 6" of 1/4" vinyl tubing.
- Feed one or two feet of a 20 feet piece of 24/2 speaker wire through the tubing (29 cents per foot for the speaker wire at Ace Hardware), and insert the tubing/wire into the new 1/4" hole.
- Clamp or seal the end of the vinyl tube that is outside the chamber top, and run the rest of the speaker wire to your e-match, ***18 or 19 feet away from you. Safety first.***
- Connect the ends of the speaker wire running inside the vacuum chamber top to your altimeter's "drogue or "main" event screw terminals.
- Turn on the altimeter, screw on the vacuum chamber top, and when ready, pull your manual vacuum pump to initiate the "flight".

You will probably think of many other uses for this outside connection. I'm using it for the testing of my main parachute deployment device, as triggered by the altimeter.

Enjoy your new toy...I mean...scientific instrument!

About the Author:

Mike Momenee began flying model rockets during the late 1960's. He says he was a science fair and research paper nut. His paper, *"Determining the Efficiency of Ducted Propulsion Systems in Model Rocketry"*, won one of ten national scholarships in a 1971 national contest, complete with a trip to Washington, DC and a group picture on the Capitol steps. Mike graduated from Notre Dame in 1975 with a science degree, and had a successful healthcare-related sales/sales management career, from which he retired in 2008. Mike and his wife Jackie, live in sunny Valrico (Tampa) Florida, and flies at the monthly TTRA launches in Plant City.

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