

The Pneumatic

SpudZooka

Model 234

How to build a pneumatic potato canon!

Rev “2003”

By

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INTRODUCTION

When I was a kid, I had the oddest fascination for building the coolest stuff. Jacobs Ladder, potato powered clocks, model rockets, crystal set radios. You name it, I either had it or wanted it. To me, that's what was cool, not MTV or Pac Man. Just give me a junior electronics kit and I'll blow a whole weekend on it.

Anybody out there remember the "polish cannon"? Sure, it wasn't as involved as the other stuff I mentioned, but it was just as fun! It was just a simple device: a few soup cans and a little lighter fluid, all that was needed to propel a tennis ball high into the air. For me it was just the thing to gain a little admiration from my friends and to drive my parents a little crazier. As I got older, my love for these "toys" never waned. Instead, it just evolved. Replacing the "duck taped" tubes with a stronger, PVC version. This was dubbed "The Potato Cannon", named for the preferred ammunition.

It has been said that the only difference between men and boys, is the size of their toys. Now that I've reached adulthood, I may have to agree with them, because now I have discovered the next version of "The Potato Cannon". It's called "The **SpudZooka**". The monster that beats all the other "spud guns". Utilizing compressed air instead of lighter fluid, it allows you to control the power of the shot, firing every time. And man, does it fire! It'll send a potato a couple of hundred yards! An incredible feat with just a little compressed air and a small vegetable.

Interested are you? Read on my friend for now you have the know-how to build your own **SpudZooka**.

Before you actually begin building your own **SpudZooka**, it may be a good idea to read through these plans until you are familiar with the construction of this device. Though this is one the most simplest pneumatic cannon I have ever seen, it still may seem a little confusing until you get a good grasp of it's function. The theory section on page 9 should give you a good understanding of how this device operates.

DISCLAIMER

These projects demand a strict respect for safety. The information provided here is for informational purposes only. The author cannot be held responsible for any property damage or bodily harm that may be inflicted by the construction, or firing of any device that is built. By nature, these devices are inherently dangerous. It is the builders, or owner's responsibility to ensure the safest use of these devices. Although good faith and effort has been made to ensure the validity of the information contained in this manual, no guarantees or assurances of accuracy are provided by anyone.

Now that we got that out of the way, lets move on to more useful and productive information.

PARTS

The following is a parts list of all components of the **SpudZooka**. You should be able to purchase most materials from your local hardware store. If you can't obtain the parts locally, try some on-line industrial suppliers like Grainger or McMaster-Carr. It is important to take your time when manufacturing any project. Garbage in, is garbage out. Take your time, understand each of the steps and why you are performing each, and you will create the ultimate potato cannon, and be envied by all your friends.

All pipe and fittings are schedule 40 PVC

Parts required to build the main structure . . .

- 1½" pipe 72" long
- 3" pipe 42" long
- 1½" to 3" bell reducer
- 3" adapter
- 3" threaded plug
- 10-32 x ¾" set screw (Qty. 3) (See page 11 for a variation instead of using these.)

Parts required to build the ramrod . . .

- ½" pipe 78" long
- ½" pipe cap

Parts to build the diaphragm . . .

- 2¾" diameter 1/8" thick rubber gasket (See making the diaphragm)
- 2¾" diameter 1/32" thick rubber gasket (See making the diaphragm)
- 2 5/8" diameter 1/32" sheet metal (See making the diaphragm)
- ¼-20 x 1/2" screw
- ¼-20 nut
- ¼" washer
- 1¼" x ¼" fender washer

Parts to attach air . . .

- ¼" brass pipe close nipple
- ¼" quick exhaust (optional, though highly recommended for faster switching of the internal diaphragm. This will give much greater distances. Also allows remote detonation of the cannon. This device can be found in most industrial supply catalogs. If you know someone in the industrial maintenance field of work, they should be able to help you out.)
- ¼" air regulator (If the air compressor you are using does not have a regulator, get one!)
- 5' of air hose
- air hose fittings to mate the above hose to 1/4" pipe fittings

Miscellaneous items . . .

- Bag of Idaho's finest (Potatoes), maybe a couple of bags would be better, because once you start, you'll soon find one bag isn't enough!

TOOLS

Though you shouldn't need any special tools to manufacture your **SpudZooka**, a well-stocked wood shop or metal shop can make assembly time faster.

- Vertical belt sander (not required, but would be very helpful)
- 1/4" gasket punch (not required, but does a nice job)
- a pair of channel locks (one should be large enough to clamp down firmly onto the adapter)
- screwdriver
- Allen wrench that fits the set screws
- #21 and a 7/16" drill bit
- PVC cleaner/primer
- PVC glue
- Teflon pipe threading tape
- tape measure
- pencil
- utility knife
- half round bastard file
- 1/4-18 NPT tap (National Pipe Thread)
- center punch
- metal cutting sheers

CUT-AWAY DRAWING

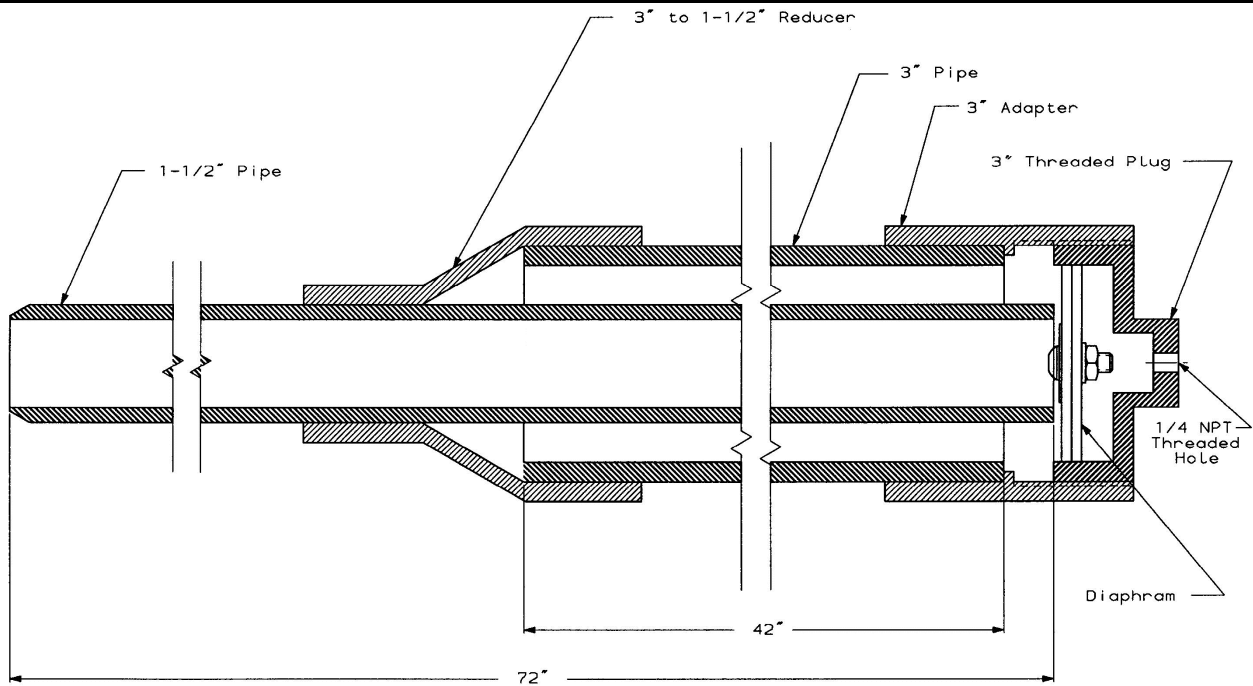


Figure 1

Internal view of the SpudZooka. Note that the set screw holes are missing for clarity.

SAFETY

DO NOT FIRE THE CANON AT ANYBODY OR ANYTHING! The potato will emerge at lethal speeds of greater than 400 feet per second. I have made pneumatic cannons that are capable of punching a potato through two ¾” pine boards and a ½” piece of plywood (giving a total thickness of 2”) at 50 feet. Understand that this is an adult toy!

This device is **NOT INTENDED TO BE HELD DURING TEST FIRING OR REGULAR FIRING** do to the possibility of the PVC plastic chamber rupturing. If this were to happen, it would cause serious or lethal damage to you. It is suggested that you shield your body from the cannon while pressurizing and firing of the device.

All PVC pipe should be clearly marked SCH-40 260 PSI. **ACCEPT NO SUBSTITUTIONS. DO NOT TRY TO USE THIN WALLED DRAIN PIPE.** It is a good idea to try and keep your body shielded from the cannon while it is pressurized. I have never heard any exploding on there own, but it is a possibility that cannot be ignored.

When gluing, make sure you are using PVC glue on PVC plastic. **ALWAYS USE PVC CLEANER. THE CLEANER IS A VERY IMPORTANT STEP IN GLUING PVC PIPE TOGETHER.** Don't listen to the old timers when they say primer/cleaner is not needed. I always seem to be the one fixing there pipes a few years down the road after they blew apart! **DO NOT SKIP THE CLEANING.** ABS glue and PVC glue are not the same. Only use ABS glue if you decide to built ALL of the components out of ABS plastic. (Note: ABS plastic does not require cleaner. Just be sure that all of your joints prior to gluing are clean and free of dirt and oils.)

PVC pipe may not the best pipe to use. It is just the easiest to find, and it is about half the price of ABS pipe. If the PVC pipe were to rupture, it would more than likely shatter into tiny fragments that would act like a hand-grenade. ABS pipe, may just rip like a paper bag, therefore not spew as many pointed, jaggy, sharp edges into you. I am not a plastic expert, and I really don't know what would happen. I am just going from experience and what I have heard from others. The risk is yours to make.

ASSEMBLY

Cut both pipes to length. The barrel pipe must have a perfectly square and smooth surface on the breach end. This is the end the diaphragm will seal against. You may have to flat file and sand it to make sure a good seal with the diaphragm is achieved. On the opposite end of the barrel, chamfer the edges to achieve a point. This will enable the spud to be cut and perfectly fit the barrel as it is inserted.



Figure 2

Chamfer barrel so that potato is cut to fit during insertion

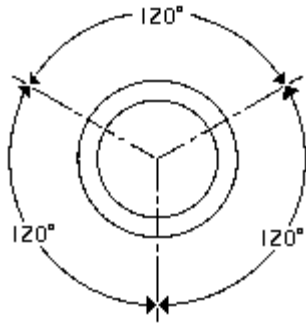


Figure 3

10-32 threaded hole position guide for barrel

On the breach end of the barrel it will be necessary to drill and tap, three evenly spaced holes around the barrel. These threaded holes are to be placed 1-3/8" from the breach end. The threaded holes will be used to center the barrel in the outer chamber later on. It is important that you do not miss this step prior to any gluing. It will be impossible to drill these holes once the barrel is glued in place. The proper drill bit to use is a #21 with a 10-32 tap. Figure 3 shows a simple guide I made to get them spaced nice and even. (A variation, in stead of using the set screws, is explained on page 11 of this manual.)

The front bell reducer has a small ridge that would prevent the barrel from being pushed through it during assembly. Use a half round file to remove the ridge. Make sure you can push the barrel through the reducer. Remove the barrel and set it aside.

Assemble the outer chamber first. Glue the bell reducer and female adapter to each end of the 3" pipe. Be sure to use PVC cleaner. I have seen low pressure water pipes push apart because cleaner was not used on the joint. Allow the glue to dry before proceeding to install the barrel. As you glue the parts together, hold them in place for 30 seconds. Glued joints tend to push apart until the glue sets.

Drill a 7/16" hole through the center of the threaded plug. Thread this hole with a 1/4-18 pipe tap. Be sure not to tap it all the way down to where you run out of threads on the tap or else the pipe will not seal properly. Also it is good to know that a 1/4-18" pipe tap is not the same as a 5/8-18 machine screw tap. A pipe tap will taper the threaded hole, so that as you spin a pipe fitting in, it will naturally tighten.



Figure 4

Drill hole through plug and tap for air supply



Figure 5

Measure depth of plug



Figure 6

Temporary bolt the positioning plug inside the threaded plug

At this point we need to make a positioning plug that will allow us to set the proper depth. Do not skip this step. Failure to use this positioning plug will not set the proper depth and all of your work up to this point on the **SpudZooka** will be for nothing because it won't work. Use a 2 7/8" hole saw to cut a 2 3/4" disk out of wood, or any material that is available, that is 1/2" thick. (Note: The thickness will be dependent on the depth of the threaded

plug. All the threaded plugs that I have checked have a 1/2" depth, but this does not guarantee that the plug you found will hold true. Measure it, and adjust the thickness of the positioning plug as necessary.)

Push the barrel through the reducer all the way through until it comes out past the adapter, so that you can get the set screws started. Wrap them with a little bit of tape so as to make a good seal. Put them in the holes, but do not place them through so far that you cannot move the barrel. You still have to be able to move the barrel in and out. We will tighten them later.



Figure 7

Alignment Marks

Place the positioning plug inside the threaded plug as in Figure 6. If it is loose and easily falls out, try bolting it to the threaded plug just to keep it from falling out during the critical gluing stage. Now spin the threaded plug with the positioning plug on as far into the adapter as you can. Mark both the adapter and threaded plug with a marker or better yet a small punch so that you know how far to spin the threaded plug back on since you will be removing it. Look at figure 7 to see how to place your alignment marks. Push on the barrel to be certain that it has bottomed out on the positioning plug. Mark the barrel at the reducer and pull it out a couple inches so that you can apply the PVC glue. Once again do not forget to use PVC cleaner. (At least

use it on the barrel, it is impossible to use the cleaner on the inside of the bell reducer. Just make sure the bell reducer is clean and you will be ok.) Apply a good 3" of glue below the line. Once your ready, push the barrel back in until it bottoms out on the positioning plug. Hold the barrel in place until the glue sets. This is a critical assembly step, so fully understand it and why you are doing it before you actually start gluing.

After the barrel has been glued in position, remove the threaded plug. You can now remove the positioning plug, and set it aside. You no longer need the positioning plug. Center the barrel and tighten up on the three centering screws. Do not over tighten the set screws. You only need them snug. You may have to have a second allen wrench which has the arm bent in order to get on the screws.



Figure 8

Center barrel in chamber with the three set screws

We will need a ramrod to push the potato down inside the barrel, and this is accomplished simply by cutting the 1/2" pipe to length and gluing the cap on. That is all it takes to make a ramrod.

MAKING THE DIAPHRAGM



Figure 9

Measure inside diameter of positioning plug

This style pneumatic cannon uses what I call a floating diaphragm assembly. Before you start making the diaphragm, the measurements listed below were for a threaded plug that measured 2.75" on the inside as in Figure 9. (Technically, the inside of this threaded plug was slightly tapered from 2.75 to 2.71.) I have found some that had a larger inside diameter. If your threaded plug does not measure 2.75" then you will have to modify your measurements, or make it a personal mission to obtain the threaded plug I used. (The company that manufactured the threaded plug I used is Charlotte.) Figure 10 shows the parts that make up the diaphragm.

The diaphragm is the most important component of the **SpudZooka**. It is very important that you take your time when manufacturing this part. The diaphragm is basically a metal disk sandwiched between two gaskets. The size of which is approximately 2 3/4" in diameter. I say approximately because it is dependent on the inside diameter of the threaded plug. (My gaskets measured 2.73".) The gaskets should be slightly smaller than the I.D. of the threaded plug, but not so loose that it falls right out. By having it a little snug, it helps to keep the diaphragm moving straight in and out. The metal plate should have a diameter that is slightly smaller than the gaskets. This will ensure that the metal does not rub the sides of the threaded plug. My metal plate measures 2 5/8" or 2.625".



Figure 10

Parts to the diaphragm



Figure 11

Homemade gasket punch

Start off with the metal plate. Draw a circle with a diameter of 2 5/8" and cut it out using metal shears. If the edges are sharp, file them smooth. Now drill a 1/4" hole through the center of your metal disk. Next, we need to cut the gaskets. One should have a thickness of 1/8" and the other should be 1/32". If you don't have these exact sizes, try them out anyway. A thinner gasket than the 1/8" may not move straight in and out, but instead get cocked and not seal. (This was my experience.) Here it would be helpful to have a lathe so that you can make your own gasket punch. The punch works just like a cookie-cutter. If you are able to use a lathe, I recommend using a metal pipe that has the ends tapered until the 2 3/4" is achieved. Then, this cutter can be used in a manual or hydraulic press to simply push through the gasket material. The end result is a perfect cut gasket. Figure 11 shows my homemade gasket punch, which was manufactured from an old piece of electrical conduit.

For those of you who do not have the luxury of the above items, a compass to draw the circles and a good x-acto blade will do. You'll just have to take your time.

After the gaskets are cut, a 1/4" hole will be necessary in the very center of each one. Again they make gasket-cutting punches that can place a 1/4" hole exactly in the center. If you don't have one, you'll have to use a drill, or taper the edges of a pipe with an inner diameter of 1/4" effectively making a punch. (This 1/4" punch made from a 6" nipple works great.) To assemble the diaphragm, place the screw through the 1 1/4" fender washer, 1/8" gasket, steel plate, than the 1/32" gasket. Place a 1/4" washer and nut on. Tighten down firmly on the nut and that's it. One diaphragm assembly completed. The diaphragm moves the distance inside the threaded plug. Be sure it feels good and snug, but not too tight. If it binds, make the gaskets slightly smaller until it moves easier.



Figure 12

The completed diaphragm

If you find that the making of the diaphragm is difficult, a complete kit is available, fully assembled. See last page for details on ordering.

FINAL ASSEMBLY OF THE CANON



Figure 13

Quick exhaust attachment



Figure 14

My Air line attachments

Screw the pipe into the "Out" side of the quick exhaust. (All quick exhausts are different in looks, but they all act the same. Check with the manufacture instructions if the ports are not labeled clearly.) Screw your hose connector into the port marked "In" on the quick exhaust. Now screw the entire assembly into the threaded plug. Be sure to use Teflon tape on all fittings to achieve a good seal. The "Exhaust" port is

not used and should not be plugged or restricted in any way. Complete assemblies are available, see last page for details on ordering.

Place the diaphragm inside the threaded plug. The 1/8" thick gasket should be facing you. Screw the threaded plug in until the marks you made earlier line up. (This will ensure you have the proper depth when the barrel was first glued. See why it is so important.) Now depending on what air fittings are available to you, will depend on how you connect to your source of compressed air. Figure 14 shows how I do it. Be certain that your disconnecting means is after your air regulator. If not, the air will have to escape through the regulator and this will slow the exhausting process and your cannon may not fire properly. (See the trouble shooting for more detail.)



Figure 15

The almighty diaphragm

That's it, your **SpudZooka** is ready for firing.

FIRING

Before you actually use a projectile, I recommend dry firing your **SpudZooka** a couple of times. You should start off at 20 PSI and increase it by 10 PSI each time. I would not recommend going over 100 PSI. You will get incredible results from your cannon as low as 40 PSI.

Next, grab your supply of potatoes and load one into the barrel by hand, then ram it down with the ramrod. (This may be a good place to remind you of the safety aspects of the device. The projectile will emerge at a lethal velocity so **DO NOT POINT AT ANY BODY OR ANYTHING, AND DO NOT HANDLE THE CANNON UNDER FIRING CONDITIONS WITH OR WITHOUT A PROJECTILE.**) I recommend **NOT POINTING IT AT YOUR SHED.** Even if you have a ½” piece of plywood in front of it, and depending on your air pressure, you stand a good chance of blowing a hole through the plywood and then through the side of your shed. Now turn on the air. Start off with a low pressure again like 20 PSI, just like you did for the test firing until you get an idea of the power the spud has. When the hissing of air stops, the outer chamber is full. To fire simply disconnect from the air source and VA-WOOMP. It's Out -a-Here!

Once you're done playing for the day, you should disassemble the diaphragm assembly and wash all the parts of the **SpudZooka**. Old potato juices tend to get a little on the musty side. Long term exposure may corrode the metal parts of the diaphragm. This won't be necessary, if you're not shooting organic compounds.

THEORY

When you first apply air to the device, the diaphragm shifts forward towards the barrel and effectively seals the air from going out the barrel. The air gets pushed out around the non-perfect edges of the seal and fills the outer chamber to the preset air pressure. As long as you have air pressure applied to the back of the diaphragm, the diaphragm will remain pressed against the barrel. Once the air is removed from the back of the diaphragm, the air pressure in the outer chamber pushes the diaphragm back against the threaded plug where the back gasket makes an airtight seal. This seal does not allow air to go back out through the threaded plug, and at the same time allows all of the air stored in the outer chamber to go out the barrel. This device is used in industry and is called a quick exhaust. It is used to allow air cylinders to vent quickly, which in turn allows a faster movement. The way we are using it, it allows the massive air flow that is required as our propellant.

This particular approach of assembly is much better than simply connecting a solenoid valve, like a 1” garden sprinkler, or a ball valve between a pressurized chamber and a barrel. This set up will switch much faster than a solenoid or ball valve and has greater airflow. This type of set up can be applied to larger pipes. I have heard arguments that a ball valve works just fine, true, but there is no way humanly possible to open a ball valve as fast as the stored pressure in the outer chamber can push a diaphragm. There is a good chance your projectile is out of the barrel before you even get that ball valve fully open.

TROUBLE SHOOTING

There really isn't a whole lot that can go wrong with a **SpudZooka**. Here are some of the minor problems I encountered while building and test firing my creation.

I tried using a thin (1/32") gasket on both sides of the plate when I manufactured my diaphragm. This didn't work very well because the diaphragm had a tendency to get cocked and failed to seal in both directions. The solution was to use the 1/8" gasket on one of the sides. I still used the thinner gasket on the backside, so as to get as much movement of the diaphragm as possible. The further it can move, the faster air will escape up the barrel.

If the air seems to slowly escape rather than a sudden burst, it could be because your airlines are too small or too long. I tried to use about 25' of air line hose, but it would not let the quick exhaust switch fast enough, which in turn did not allow the main diaphragm to move fast enough. You also get this affect if you do not use a quick-exhaust. Speed is important to get a good firing of the **SpudZooka**.

I tried to cut corners with my fittings. One way was to disconnect the airline before the air regulator. This coupled with a long air hose did not allow the quick exhaust to shift fast enough. The solution was to disconnect the airline after the regulator. It required a couple of extra fittings, but it worked flawlessly. Figure 14 shows my air line attachment fittings.

If you are finding that your cannon is taking too long to charge, this could be caused by the close tolerances of the metal plate and the gasket materials. The air must seep out around the gaskets to charge the cannon. If this doesn't happen, or is taking too long, I offer a solution. See Figure 16. Basically we turn the diaphragm into a check valve that allows more air volume to flow while charging, and closing while firing. This is accomplished by drilling two 3/16" holes through the thin gasket and the metal washer, but **not the 1/8" thick gasket**. Because of the holes in the thin gasket, it may bend over. If this occurs, simply use silicone as glue, and attach it to the metal washer.

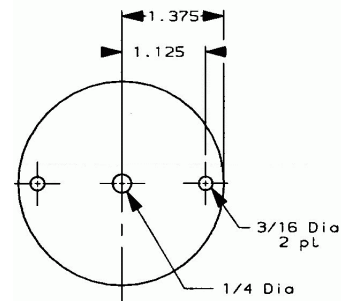


Figure 16
Diaphragm modification.

I have had some firings that just didn't seem to have any distance. After the 4th shot, they really started to sail. I believe it was do to the rubber gaskets not sliding properly or because of the problem above. The gaskets may have sealed the airflow at a lower pressure than what you are charging at, and you never reach your full charge. After the first couple of shots, I believe the potato juices aided in lubrication. So, if your not shooting any vegetables, and it doesn't seem to give the distance your expecting, try lubricating the inner sides of the threaded plug with your favorite lubricant, be it grease or WD-40 or try modifying the diaphragm as described in the previous paragraph. If you try a lubricate first, find something that won't attack the gasket material.

VARIATIONS

The barrel can also be centered with out using set screws. See Figure 8 for the set screw approach. In place of the set screws, you would substitute ¼" x 1" x ~3/4" thick strips of PVC that are glued in place of the set screws. The PVC strips must fit snug prior to gluing or there is the chance of them breaking away under the stress of firing of the cannon. The advantage of this approach makes it a little easier to manufacture. My original cannons used this idea, but I opted for the set screws to distribute the plans because they are more readily available than finding sheets of PVC. **(If you use the PVC strips, you no longer need the three threaded holes in the barrel so don't drill them.)**

TECHNICAL CALCULATIONS

For you guys that have no industrial experience, here is an area that will give you an understanding of how much force you are really dealing with when it comes to compressed air, and why it can be so dangerous. First of all, air is a gas, and therefore it can be compressed a lot. Unlike liquids which do not compress very well if at all. If you filled your **SpudZooka** with 40PSI of water, as soon as it would be fired, the water pressure would immediately drop and you would be lucky if the spud even came out the barrel. Since air is compressed a lot more, it can expand and it will maintain pressure as it's pushing the spud out of the barrel.

To get an idea of the force that is placed on your spud, you must first have the formula to calculate area.

$$a = \pi r^2$$

Using the above formula, on a 3" threaded plug at just 100PSI, we calculate a force of 707lbs. In other words, the threaded plug is being pushed by 707lbs of force. If you were sitting on it, and it ruptured, you would go flying.

The force on a spud in a 1.5" tube and 100PSI would be 177lbs. Not nearly as much as the threaded plug, but you're launching a mere 1/4 pound spud.

CONCLUSION

Now that you have created a more sophisticated potato cannon, you will now be able to impress those you love dearly, your kids, your friends, and even your wife. (Well, maybe not your wife!)

The plans provided here are an excellent start for the serious spudsman. Feel free to modify the design and branch out on your own, but do keep in mind the seriousness of safety. Have any ideas to improve the finished product, drop me an e-mail.

If you are interested in the latest info on what I have to offer, visit my web site at . . .

WWW.SPUDZOOKA.NET

Here you will find additional information and feedback from happy spudders.

If you are looking for something interesting to shoot from your cannon, check out . . .

WWW.SPUDGUN.COM

Here they sell small rockets that you can attach glow sticks, and fire them into the night sky. They look like tracer bullets as they sore into the heavens. You can also purchase rifled barrels if you are serious about distance shooting or modifying your cannons. Cool stuff, you need to check this site out!

If you are having problems building the diaphragm, visit **WWW.SPUDZOOKA.NET**. Here I have some of the more complicated components to build the **SpudZooka** for sale.

If you want to drop me a note, log onto **WWW.SPUDZOOKA.NET** and somewhere within those pages, you will find multiple e-mail links that will point you to me.

Have fun and please be safe with your **SpudZooka**.