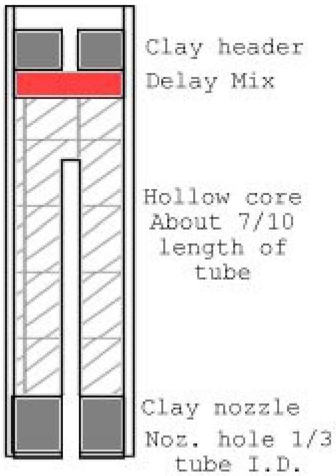
Rockets and Rocket Experiments

A 3/8” rocket ready to rock. This one went to a couple hundred feet.
There was a black powder charge in it (mostly to signal the end of the delay and to let me see where it fired)

Rockets
(General)



Cases

Rocket cases are generally made from convolute tubing rather than spiral wound tubes. Toilet paper tubes are spiral wound - most of the rocket cases in the pictures below are convolute except the 1/4" tubes - notice that the wrapping seam on the convolute tubes is not spiral but just a straight seam that runs down the tube. A 1/2" case should have about a 1/8" sidewall to insure it can hold the pressures from the burning composition. Usually, a

1/16" wall tube is for salutes - not rocket motors. You can wrap your own small cases easily - use gummed paper tape and a waxed stick of the proper size. Keep it 1/2" or less for your first few tries - go easy on the water on the tape - pull case off stick quickly. You may have to figure a way to hold the outside flap on the case until everything dries.

Nozzle Size

A good starting nozzle diameter for a rocket is usually 1/3 the I.D. of the case. However, the nozzle can be opened up to 3/8 of tube I.D. which allows very hot fuel, gets fair altitude, and is much more reliable (less likely to CATO). You can get very involved in nozzle designs... Here is a modified post I made on Passfire:

Nozzle design isn't exceptionally magical with our pyro rockets. You can get by with variations without getting a lot of erosion or noticable loss of impulse.

The idea behind any nozzle is to efficiently convert high pressure to high velocity. In most earthly cases, it is good if the pressure of the gasses at the exit are equal to the atmosphere - meaning all pressure was converted to thrust. In this context, the divergent angle is the most important and also the most difficult to make perfectly for our motors. If you can be sure of a constant pressure then you can tune the nozzle convergence/divergence and other parameters and improve performance - to a point. The ideal divergent section may well be too long to be practical in a pyro rocket that uses clay as the nozzle material. The weight of the nozzle would equal the rest of the motor in some designs. Also, our pyro rockets never give constant pressure so the ideal design will always be a compromise.

A modified convergent/divergent section is about as good as we can do - it is better than no taper which causes dead spots, leads to erosion, loss of impulse, poor conversion of thermal energy and maybe CATO. Most have recommended the 60/30 convergent/divergent angle. In practice, even 45/45 works fairly well but 60/30 is easy to do with a clay nozzle. See the BP tooling design below to understand which angle is which.

Nozzle Composition

Clay can be straight kitty litter or dry pottery clay or Hawthorne clay or a variety of other clays. Do not wet the clay. It will compact hard as a rock. Having said that, some people like to add 10% or so oil - just about any type - or toilet wax warmed and thinned with Coleman fuel. Oiled clay compacts easier and is less likely to be affected by high humidity. Clay without oil tends to expand in wet weather - and if your motor is on the red line, the decrease in the nozzle opening could make it CATO.. Others like to add grog (ceramic dust) with the oil/wax thinking that it grabs the sides of the cardboard better. I don't like to add grog because, if I have to ream the clay out or make a passfire, the grog is a spark producer. For most rockets you can get by with lightly oiled clay.

Bulkhead

Here is how the pass-through hole is made. A wire is placed on top of the delay, clay is poured around it, the whole thing is tamped with a hollow drift (same one that is used to tamp the fuel). Notice the clay pulled away around the wire. That is because it wasn't pressed in hard enough. Below is another picture of a couple of 5/8" motors that had the bulkhead pressed on. Nice and clean, eh?

Stabilizing Sticks

Make them thin but not weak. The length should be about 6 times the length of the motor (minimum). Use pine and rip them out on a table saw or use cat-tail reeds or bamboo garden stakes or 1/8" round dowel or food skewers (for 1/4" motors) or ....???

Delay Charges

The most common delay composition is just more of the fuel packed above the end of the core.

Any of the various charcoal star compositions work well as a delay charge. Try Chrysanthemum #6 (see the compositions section).

Cheap Tooling

Rocket tools can be expensive or cheap. The cheapest tools are just pieces of hard wood doweling.   To make an inexpensive set of 1/2" tooling:

> Buy the following from a hardware store:

1 length of 1/2" dowel
1 piece of 3/16" brass rod
If you don't have an old piece of wood, then buy a short 2x4 while you are at it.

Drill a 3/16" hole about 1" deep in a 4" or 5" piece of wood.

Cut a piece of the 3/16" brass rod to about 3" to 3 1/2"

Smooth the ends of the rod with a file or sandpaper - you can also taper it a bit if you wish by putting it in an electric drill and running it across some sandpaper. But you might not have to do so and it might be worth trying it 'as is' since getting the taper right and then getting it smooth afterwards is a pain. Coat it with PAM or similar non-stick cooking spray (or graphite or candle wax) to get it to release easily.

Cut a 6" piece of dowel and drill a 3/16" hole up the center. Be sure the dowel fits easily over the brass rod (it is ok to ream it out to 1/64" over if necessary).

Put the brass rod in the hole in the wood and put a cardboard tube over it.

Proceed to fill the tube with clay/propellant/delay/bulkhead. Put in no more than 1 diameter of material, then tamp with the hollow dowel. Use 10 firm smacks with a dead blow hammer or wooden mallet. Don't hit it hard but DO make the increments small (very important!).

For smaller rockets (1/4" to 1/2") I use a dead blow hammer or arbor press depending on the composition - ramming should only be done with BP! If your BP is granular (pulverone or similar) then you need to compact it harder to consolidate the granules into one long grain (see the fuel section below). Generally, powdered BP (meal powder) compacts easiest - especially if you use small increments.

When the core is covered with powder, then finish tamping in one more increment (one more diameter) of powder, a delay (which is usually more of the same powder), and the kitty litter bulkhead. Use a piece of dowel that doesn't have a hole in it to tamp the powder above the spindle. If you need a passfire (a hole in the bulkhead to allow fire to get to your header) then you can consider adding it in but get the basic rocket motor working first.

When done, remove the brass core with

a pair of pliers - gently twist it around in a circle and gently pull out at the same time - don't wiggle it back and forth. If you crack the grain at this stage, it will CATO (explode) when you try to launch it so be gentle.

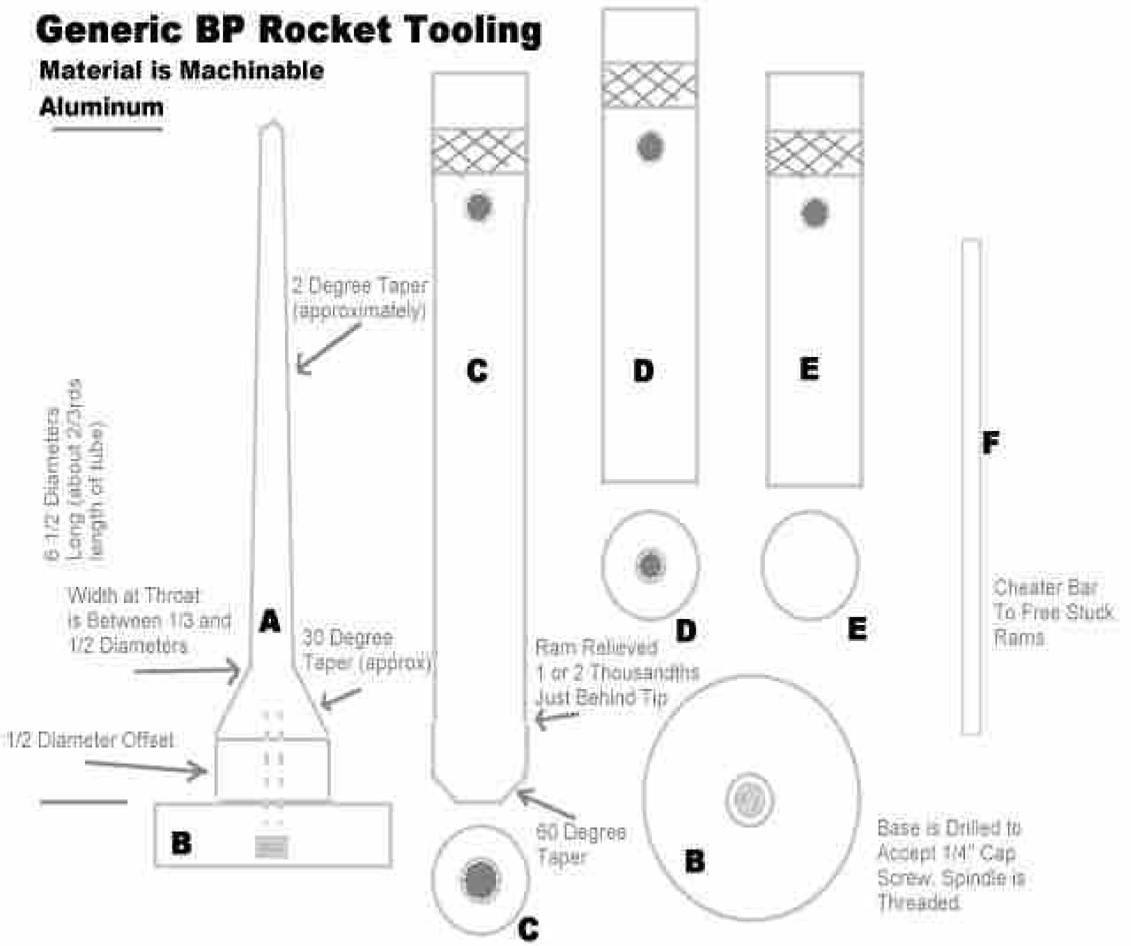
Fuse the rocket with Visco or similar. It is easiest to just tape the fuse in the hole with masking tape - although a more elegant approach is to use tissue paper and wedge the fuse in the hole.

An Easter Egg Payload (works great!)
The stick is a bamboo garden stick

Tape the motor to a stick that is about six times the motor length. After the basic length is met, don't worry too much about balance, it will probably fly if the motor is good.

For BP on 3/4" and higher I use a 4 to 6 pound hard split hammer or the press. I was using a dead blow for the bigger tubes and was getting an occasional CATO. Dan Thames lent me his 'Barney Rubble' hammer at PGI and that eliminated the CATOs. (see: http://www1.mscdirect.com/CGI/NNSRIT?PMAKA=97133417&PMCTLG=00). It works much better for larger motors - you can actually feel the composition compact and you know when it is properly smooshed. I use the hard tips (http://www1.mscdirect.com/CGI/NNSRIT?PMAKA=63282263) which give the best feel. It is a bit big for motors less than 3/4"- use a one or two pound dead blow hammer for those.

Above are some machined rocket tools made from scrap material in a shop. You can also just make the tooling from wooden doweling. The longer core on the left will require a much cooler fuel (RP or similar). The one on the right can take a hotter fuel. Neither set of tools has a proper convergent/divergent angle but they still fly swell!



Above is a general guide for creating BP rocket tooling from aluminum stock. You can vary these measurements slightly depending on your particular need. If you are just starting to make your tooling, try to get it close to these measurements and vary your fuel to get the performance you desire. This tooling works fine for nozzleless designs, too.

A. Spindle that is 6 1/2 diameters long (approximately). The diameter at the throat (where the 30 degree taper starts) should be more than 1/3 the width of the tube. Commercial tooling is usually just a bit under 1/2 the width and the nozzle then tapers inward so that the clay bulkhead ends up choking the nozzle just a bit smaller before the fuel grain starts. The length of the spindle should be about 2/3rds the length of the tube (commercial spindles are sometimes up to 3/4 the length but they don't leave enough room for delay/garnish or headers).

B. Base. Keep it small enough that you can put it in a vice
C. First ram - note the taper on the end. The center hole does not have to go completely through (and probably shouldn't). Ram is usually marked to indicate if it is too close to the bottom of the tube (thus ruining the spindle). The length is the length of the tube plus 2".
D. Second ram. Ram is usually marked to prevent jamming on spindle. It is 2/3 length of the first ram.
E. Third ram - solid - also marked. It is 1/2 length of the first ram.
F. Cheater bar to free stuck rams. When pressing, the material will sometimes ooze around the ram and stick it. The cheater bar helps to free the ram. The usual solution to sticking rams is to use smaller increments of composition.

For basic information about whistle rocket tools, go here - whistles.html

More Expensive Tooling

Commercial 3/4" (one pound) Whistle Rocket Tooling
Whistle rockets use a shorter and wider spindle.

You can get custom tooling from several sources on the web. Look up Wolter Pyro Tools, Skylighter, FireFox, Cannonfuse, Pyrocreations, and more for some quotes. You can also make your own if you have a small lathe or mill. Custom tooling is very nice but usually not necessary at first.

Fuel

Fuel should be hot enough so the rocket doesn't 'chuff' and cool enough so it doesn't blow up. Lots of factors affect this so start with a cooler mix and work up to something that provides good performance and doesn't blow up (CATO). See RP and RPH in the composition section for example fuels. Here is a rocket that still worked but 'chuffed' listen to the sound when it launches: fiveEighthsShell1a.wmv The solution was to put hotter fuel in it.

Note that fuel issues can drive you a bit buggy. Super-hot paulownia based BP pulverone that is ideal for a light ramming in a nozzleless design (see nozzleless) will cause CATOs after it has been on the shelf for a few months. The best that can be figured is that the fuel dries up completely and the grains become hard enough that light packing isn't sufficient to consolidate the grains - thus causing cracks and CATOs. The same fuel when re-milled and packed in as dust works fine. This theory comes to mind when observing the use of 2Fa grains as a rocket fuel. They are very crunchy and very hard - pressing them to 8000 pounds will not consolidate them enough to stop a CATO! So, if you start running into strange CATO situations think about either ramming really hard or milling your BP to dust and tamping it that way.

> **Mineral Oil and BP.** My new personal favorite is to use super hot BP with +3% mineral oil added. Mix the mineral oil with lacquer thinner and then mix that with the BP and dry for 24 hours. Typically, I use 10 parts lacquer thinner to 1 part mineral oil. The thinner is to make incorporating the mineral oil into the BP easier. The BP is not granulated or made to pulverone, rather it is used as it comes from the ball mill. The mineral oil keeps the dust down and the small grain is *very* easy to compact.

The mineral oil *does* slow the BP down just a bit but that generally isn't a problem. Instead of mineral oil, some use motor oil.. Some have used WD40 (bulk, not spray) and still others have used Vaseline - similar to the way it is done with whistles. I got the idea many moons ago from the r-bp group who have been using it for a while.

Mineral oil is a little expensive but it is nice and clean and a bottle lasts a long time. Baby oil, which is 99%+ mineral oil is just as nice and it smells good - and it is a buck for a large bottle in a dollar store.

You would think adding oil would make it messier - but it makes the whole task much cleaner. You also avoid the pulverone step (wetting, screening, drying) although you have to mix the mineral oil in and dry that. I make about 2 kilos at a time and mix it in a large plastic bucket. I spread it out on aluminum pans and let it dry for at least 24 hours.

The compressed grain is smooth and very professional looking - and it holds together much better. It looks like it was cast into place (well.. a little bit - see: http://www.wichitabuggywhip.com/fireworks/rockets/nozzleless5eighths1.jpg). In addition, and if you use a firm-faced hammer, you get a better feel for grain compression when tamping. You can feel the grain come together and then stop compressing - thus you know when to stop tamping.

End Burners

Rockets can also use hot fuel and just burn from the end without much of a core. These motors can also be very satisfying. You can buy specialized tools to make end burners (for Girandola drivers and such) or you can just make a convergent and divergent cone in a clay nozzle and bore a 1/4 I.D. hole (as a start). Here is an example picture. See the Girandola sections for end-burners in flight.