Amateur Pyrotechnics

by

Dan Williams

Howdy and welcome! I assume you're here because you share my passion for display pyrotechnics. If not, you're still welcome to browse around, but be forwarned. They say that "He who hath once smelt the smoke is ne'er again free." These pages will teach you a few things about how to create art with light from the combustion of energetic materials. The information is geared for the limited budget amateur who creates his art for the sole purpose of giving delight to his friends and neighbors without thought for commercial gain. Please make yourself at home and be sure to send me a line if you've had a pleasant stay.



"One Who Hath Smelt the Smoke, is never again free"

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Projects for the Amateur Pyrotechnician

The best way for the apprentice (or the less kind descriptor "newbie") pyrotechnician to learn the trade is to do projects under the tutelage of a seasoned mentor. Unfortunately, these rare individuals who are willing to pass on their knowledge are hard to find. These pages are a small attempt to address the need to provide instruction about common pyrotechnic projects. With pictures and textual descriptions, these project pages may approximate the next best alternative to having a real pyro expert in your workshop. Most of the projects will describe the construction of finished display items or components which are used in many common display pieces.

Home Manufacture of Black Powder

Black powder is an essential component of many different kinds of fireworks items. It's a lot of work to make your own, but the satisfaction of mastering the art is well worth it.

Quick and Easy Mines

I don't particularly like the traditional name given to this class of ground effect because the word "mine" is associated with the notorious military device of the same name, but I do particularly like the beauty of the effect and the ease of construction. I think you'll agree that these three inch mines are about as easy to make as a greasy cheeseburger.

Super Sparklers

The lowly sparkler may not occupy a position of grand importance in the hierarchy of fireworks inventions, but these super sparklers will definitely command some respect and may possibly force you to realizeyour opinion of what to expect from a sparkler.

Thermalite Equivalent Igniter Fuse

This stuff isn't quite like the commercial product, but it is a good approximation that I find extremely useful. The method of manufacture was originally proposed by Firefox. I have adapted the method to my own taste and present it here as a useful way to make your own igniter fuse.

Roman Candles

The Romans had a good idea when they came up with this one. If you think you might want to learn how to make your own candles, then by all means, take a look.

Stinger Missiles

If you like rockets, you can't go wrong with this project. Why they are called <u>stinger missiles</u> is beyond me, but I'm just crazy about 'em all the same.

Clark's Giant Steel Fountain

Tired of those wimpy little store-bought fountains? This project will revolutionize your concept of a giant fountain if you think you're ambitious enough to tackle it. It's all done on a grand scale and the results are commensurate with its size.

6 Pound End Burning Rockets

Here's a project for all you rocket fanatics. These end burners are a scaled up version of the ubiquitous Estes model rocket motors, but, be warned, this project requires some specialized tooling and tubes that make it out of reach for the beginner.

Tools and Tips for the Amateur Pyrotechnician

Most hobbies require a fairly extensive set of special tools to support them. The hobby of pyrotechnics is certainly no exception. I have found that building tools has been almost as enjoyable as the creation of pleasing pyrotechnic displays. Most of the projects described on these pages involve the building of the essential tools of the trade. Some of the smaller pages fit better into the category of "tips". I hope you find these descriptions useful. If they help anyone become converted to the marvelous field of amateur display pyrotechnics, then they have served their intended purpose.

Easy Screens

The following description will let you build screen boxes that are light-weight, inexpensive, stackable and easily cleaned.

Improved Funnel Idea

Tired of making a mess when trying to load compositions into tubes? Try this idea.

Home-made Balance Scale

You can spend a hundred bucks on a triple-beam balance scale. A nice electronic scale can cost you much more, but this home-made balance scale is a very inexpensive alternative.

A Simple Hydraulic

Press

Now this is a "real" man's tool!! It does the trick for pressing black powder cakes, rockets, whistles, comets...whatever. Here's a plan for even the modestly talented tool maker.

An Efficient Ball Mill

Do you really want to keep making black powder by the CIA method!! Make a ball mill and join the ranks of serious amateur pyrotechnicians. This one uses the leading edge techniques of the venerable Lloyd E. Sponenburgh.

A Charcoal Cooker

The best black powder requires the best charcoal. If you want to make your own, you can build this hi tech charcoal cooker and make a nice black mess to rival anything your kids can do.

Tips for Fountain Tooling

Whether you're an old hand at making fountains or are looking to make your first set of tooling, these tips might be helpful.

A Powder Die

If you want to make hard grained black powder that compares with commercial quality, you will need a powder die to make your press cake. This design comes from Lloyd Sponenburgh.

Jars for your Ball Mill

If you plan to make a ball mill, then you will probably want to make some milling jars to use with it (unless you only plan to use it to mix your

margaritas).

Comet Tooling

So you're ready to try making comets. Professional comet tooling can be very expensive. This set of home-made comet tools might be a little easier on your budget and should yield similar results.

A Star Cutting Board

A good place for the beginner to start learning how to make stars is on a star cutting board. This page uses psychedelic star dough to demonstrate the tooling.

Perfect Sticky Match

It's not as hard as you might think to make sticky match as well as the professionals. Give it a try and see if you agree.

A Star Plate

If you have a little... no, make that a LOT of spare time, you can use it to make this beautifully artistic plexiglass star plate. Even if you never use it to make stars, it would make a great piece of techno pop art.

A Star Roller Adaptation

Here's an idea that borders on the bizarre. If you haven't built your ball mill yet, you might consider designing it to accommodate this adaptation which will allow it to also perform the function of a star roller machine. However, if the idea is a little too weird for your tastes, this implementation will at least illustrate the general concepts of how to build a machine that can create those most essential and marvelous little round stars.

A Black Powder Burn Rate Tester

For those of you who base your virility on the speed of your black powder, this burn rate tester design will help you tune your manufacturing process to achieve the optimum results. It has certainly helped me feel a little more masculine. My fastest black powder clocks in at over 170 cm/second!!

Links to other pyro tools sites on the web

• Wouter Visser has a page about making a ball mill <u>www.wfvisser.dds.nl/EN/ballmill_EN.html</u>

Links to sites where pyro tools are sold

- <u>www.firefox-fx.com</u> sells a variety of rocket building supplies, including tooling for BP rockets.
- <u>www.banzai-net.com/impulse-reactions/index.html</u> specializes in rocket tooling.
- <u>www.skylighter.com</u> specializes in pyro chemicals and supplies, but includes a few pyro tools.
- <u>http://deskmedia.com/%7Ehalpatbn/HAROLD1.htmHal</u> Bentley makes beautiful rocket spindles and his prices are almost unbelievable!

Projects for the Amateur Pyrotechnician

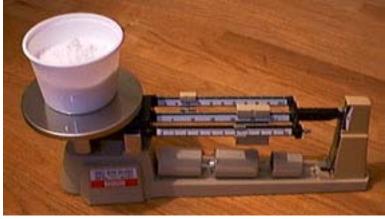
Home Manufacture of Black Powder

Without black powder in all its varieties, it would be tough to make much more than sparklers for pyrotechnical displays. Making high performing black powder is one of the fundamental skills that the aspiring pyrotechnician will probably want to master early in his quest for knowledge in the field. The goal of this meager treatise is to illustrate the most popular method of amateur production which is called the "ball milling method." This implies that anyone who wants to use this approach will need to first build or have access to an efficient ball mill. Without a mill, one is left with the inferior alternatives of using the CIA (precipitation) method or the incredibly laborious mortar and pestle method.



The first step in the process is to assemble the raw materials. In this case, there are only three, as pictured: potassium nitrate, charcoal and sulfur. Of these three, potassium nitrate and sulfur can readily be purchased from pyro supply companies such as Skylighter or Iowa Pyro Supply, but charcoal is a different story. The subject of charcoal could require a whole book to adequately cover. For the purpose of brevity, this text will assume that willow charcoal is one of the most popular choices for making high performance black powder. Unfortunately, commercial sources (at least in the US) for this particular kind of charcoal are very rare. The best approach is to make it yourself with a home-made charcoal cooker. Then you can control some of the characteristics of your charcoal by custom cooking it to your liking. .





If you make your own charcoal, you need to reduce it from the original sticks to a more usable powder form. I use the meat grinder method shown here. A guide chute has been fashioned from a sheet of transparency film to help keep the dust down. This is definitely not a job to do in your kitchen unless you want to risk sleeping in the garage for a month. A good respirator is also recommended. The result is a charcoal powder which ranges from air float to about -8 mesh. This may or may not be useful "as is" for making black powder, depending upon the approach used to make the green meal. Hopefully, this will become clear in a moment.

Regardless of the method used to make the green meal, the proper proportions can only be achieved by weighing them on a scale. I generally use the traditional ratio of 75 parts potassium nitrate, 15 parts charcoal and 10 parts sulfur. If your black powder is intended primarily for use as lift powder, you might want to use the ratio which is purported to

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be optimized for this purpose. It is 74 parts potassium nitrate, 14 parts charcoal and 12 parts sulfur. Just remember that these are parts by weight. It seems that every "newbie" to pyrotechnics will reveal his ignorance by asking the question concerning whether parts in a formula refers to weight or volume. Save yourself the embarrassment and etch upon your mind that pyro formulas are always in parts by weight unless specifically stated otherwise. The triple-beam balance scale shown does the trick quite nicely for weighing out parts of a formulation, but you can accomplish the same purpose with a much less expensive homemade scale .

Let's diverge to a little background discussion for a minute. The green meal referenced above is the raw, unprocessed mixture of the constituent ingredients. There are two basic approaches to creating this initial mixture. One method is to create a bulk mixture from which a "volume measured" portion is taken and placed in the milling jar. The other approach is to create a batch of green mix which is exactly the amount needed for the intended milling jar charge. In the first case, the particle size of the individual components of the mix must be small enough to assure homogeneity. In the second case, there is no concern about the green meal being homogeneous. The potassium nitrate and sulfur can be full of lumps and the charcoal can be very coarse. The proper weight portions are just loaded into the mill iar and the milling accomplishes the homogeneity. The second approach has many advantages, but it can only be done if the user knows the exact weight of the optimum charge for his milling jar. For the purposes of this discussion, the definition of an optimum charge is the following: the amount of fully milled black powder meal which occupies 25% of the mill jar volume. The determination of this optimum charge is challenging because milling will often alter the volume of that which is milled. The best way to determine the weight of the optimum charge is to actually weigh the desired volume of finished meal. This implies that the user of a new milling jar must use the first approach to making green meal for his first batch. The optimum charge is then determined and can be used for all succeeding

batches.



The first approach to making green meal will be demonstrated because it also includes many principles of properly mixing pyrotechnic chemicals. In general, successful pyrotechnic compositions work well because their proportions of ingredients have been very carefully determined. If the pyrotechnician allows the proportions of his mixture to vary from the ideal, the performance of the composition will usually suffer. Therefore, except in a few unusual cases, a high degree of homogeneity is desired in pyrotechnic mixes. One of the best ways to accomplish this is by using screening (which requires a good set of mixing screens) as a means of mixing pyro chemicals together. In the picture at the left, is shown the results of screening a mixture of the potassium nitrate and sulfur which were weighed out for the bulk black powder green mix. The two chemicals were stirred together and appeared well mixed. However, upon passing the



mixture through a 40 mesh screen, many large lumps of sulfur are revealed. These lumps obviously destroy the homogeneity of the mix in their near vicinity.

In order to eliminate these lumps, I perform a rough approximation to a mortar and pestle operation by placing the lumps in a container. The lumps are crushed by the back of a spoon against the sides of the container. The contents of the container are then returned to the mixing screen box and the cycle is repeated until all of the material passes through the screen. The entire quantity of mix is then passed through the screen several more times to ensure a thorough mixture. This method works well if the lumps aren't hard and dense. If they are too hard to crush easily, the best way to eliminate them is by milling each chemical separately prior to mixing with others. Now, to complete the black powder green mix, the charcoal must be added. The screening method could have been used to mix all three chemicals together



in one step, but I prefer to add the charcoal as an "airfloat" which will be free of coarse particles. The charcoal is added to a container with the screened potassium nitrate and sulfur, a tight lid is used to close the container and the container is shaken vigorously. I do this because screening any mix which contains fine charcoal will usually result in a lot of airborne dust which enters the lungs and coats the pyro lab with a nasty black film. At this point, a black powder green meal with a reasonable degree of homogeneity has been achieved.

Now a volume of green meal equal to 25% of the mill jar volume is measured. For this jar, that volume is 3 and 1/4 cups of our bulk green meal. This is the first approximation to the theoretically ideal mill jar charge. It is added to the jar along with hardened lead milling media equal to 1/2 of the mill jar volume. In my experience, the volume of the black powder meal will increase during the milling. If you have a high efficiency mill, the milling process will be complete in about 3 hours of



milling time. I would be remiss if I didn't mention that the milling should be done with all the due precautions taken. This means locating the mill remotely and perhaps using protective barriers around it.

The powder which results from the milling process is still referred to as "meal" because it is not yet very useful for pyrotechnic applications. However, it is no longer called green meal. The meal is processed into grains of black powder by a method known as corning. The size and characteristics of these grains will determine some of the aspects of the performance of the finished black powder. The first step in the corning procedure is accomplished by using a powder die to compress the milled powder into "press cake". One of the secrets of making durable black powder grains is to add sufficient moisture to the meal prior to pressing it into the cake. I add 4 grams of 50% water/50% alcohol to 119 grams of milled meal to make an individual die batch. This is done by placing the meal



and water/alcohol in a mixing cup and stirring vigorously with a stirring rod. The milled powder will undergo a fairly rapid transition from fluffy, loose powder to a stiff, but still crumbly powder when the moisture becomes well distributed. Some will advocate adding moisture by misting it lightly onto a pile of milled powder while mixing with the diapering method. Theoretically, this avoids degrading the performance of the powder by not giving the potassium nitrate a chance to dissolve and recrystallize. However, I have found this trouble to be unnecessary. The picture shows the dampened. milled powder being added to the powder die, after which the compression piston is placed on top.

Next, the die is placed in a homemade hydraulic press and the press is operated from behind the blast shield. This picture is illustrative of the pressing step, but in actual operation I recommend the use of a heavy glove on the hand which is used to pump the hydraulic jack. This and a heavy sleeved shirt or coat are a good idea. The die



has been designed so that the finished press cake has the desired density of 1.7 grams/cc.

These are the puck shaped pieces of press cake which are extracted from the powder die after pressing has been completed. They are rock hard and should hold together well without crumbling. If the press cake crumbles easily, this is one indication that insufficient moisture was added to the milled powder. The press cake pucks are allowed to air dry for at least 24 hours before they are crushed into powder grains. Tapping on the pucks with a wooden dowel makes a china-like clinking noise even right from the powder die. After drying for a day or so, the pucks will ring even a little more, indicating that the moisture level is about right for the final step of the corning procedure.

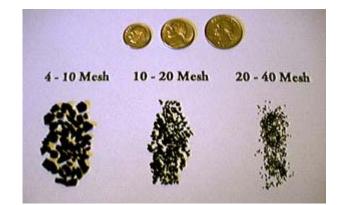


Crushing the press cake into useful grains is somewhat nerve-wracking for me, but I like this step because it is the last in a long series required to finally obtain high performance black powder. I use a small baseball bat to crush about 1/2 of a press cake puck at a time. The chunk of press cake is placed in an old aluminum pressure cooker pan and the bat is used in short, downward strokes to break up the cake. This works best if the pan is placed on a very hard surface, such as concrete or stone. The idea is to fracture the cake into grains without crushing it back into useless powder. Again, for safety's sake, this should be done outdoors with protective clothing and always avoid placing your face directly over the pan. If 60 grams of black powder were to ignite in the pan, it would create a hot flame as much as 4 feet high before your reaction time would allow you to get out of the way. As I said, this step is a little nerve-wracking, but I have never had an accident during this step yet. There may be some arguments for using a plastic bucket instead of an



aluminum pan, but I'll leave this choice open to discussion.

The contents of the crushing pan are emptied into a stack of screens to separate the various desired grain sizes. Whatever will not pass through the top screen is returned to the pan for more crushing with the "bat pestle" and this cycle is repeated until all the black powder cake passes through the first screen. A little side to side shaking of the screen stack during each cycle helps the grains settle to their proper location in the stack. This particular stack of screen boxes consists of the catch box, a 40 mesh, a 20 mesh, a 10 mesh and a 4 mesh screen on top. The powder which falls clear to the catch pan is a -40 mesh powder which is retained for use whenever meal D is called for in my pyro formulas. The powder in the 40 mesh box is a 20 to 40 mesh powder which is used as 4FA equivalent. The powder in the 20 mesh box is a 10 to 20 mesh powder which is used as 3FA equivalent. Finally, the powder in the 10 mesh box is a 4 to 10 mesh powder which is



used as 2FA equivalent.

This picture is shown to give an idea of the various grain sizes relative to common US coins. Now I'd like to explain a little about my philosophy regarding my choice of screens for separating the grains into these ranges. The ranges don't conform exactly to those given for the common commercially produced powders and this is intentional. The only motivation I can think of to conform more closely with the commercial definitions for black powders is to enable a completely transparent exchange of commercial and home-made powders in pyrotechnic projects. In these cases, the pyro craftsman wants his homemanufactured powders to perform identically to commercial powders so that he can always expect consistent end results. In my case, I don't use commercial powders. Therefore, I can afford the luxury of adjusting the amounts of powders used in my projects according to

the desired results. This way, my only concern is to make my own manufacturing process very consistent so that my home-made powders always give me the same results. The advantage of this approach is that the ranges of grain sizes for my equivalent powders don't overlap as they do in the commercial ranges. This means that I can use commonly available screens and do multiple separations in one step as illustrated above.

Finally, I am compelled to add a few words of caution and disclaimer to this brief explanation. Remember that the manufacture of black powders is a regulated activity in many areas. One should do some research into the legal requirements before attempting to do any of these steps. The procedures described represent my own experience and are not necessarily recommended as the final word in how to do it properly and safely. These explanations are made available to others in order to stimulate constructive dialog for enhancement or improvement.

Quick and Easy Mines

I am partial to fireworks mines because they allow the viewing audience to be a little closer to the burning stars. This is true because a mine is a ground effect and ground effects, in general, are more predictable and controllable than aerial effects. Mines are also simpler to make because there is no need to contrive a delay mechanism or a reliable burst charge to achieve a desired pattern in the sky. There are many ways to make mines for different kinds of results, but the approach described here is about the simplest I've seen and produces a pleasing, bushy column of burning stars. The technique is used for making mines for a 3 inch mortar, but the principles should apply to mines of many sizes.



The first task is to scrounge around for a former that is the right size. Here is a picture of a water bottle that is about 1/4 inch smaller in diameter than the mortar used to fire the finished mine.



A common, ordinary brown paper bag, such as a lunch bag, is folded neatly around the former or sloppily scrunched around it, depending on the artisan's personal style. A few wraps of packing tape will assure that the original shape of the former will be retained by the bag upon removal of the former. Now, you could painstakingly construct a cylindrical mine bag by custom cutting a piece of craft paper to roll around the former. but either approach will produce a result which is pretty much functionally equivalent. I'll take the quick and easy way any time. If a lunch sack is used to make the mine bag, the top 4 inches will need to be trimmed off after removal from the water bottle former.



Next, we need a leader fuse that is long enough to protrude from the mortar by about 12 inches. My mine mortars are 20 inches tall so I make a leader that is about 3 feet long. For single shot mine mortars, a length of home-made sticky match will do nicely. The picture shows a length of match with a piece of visco at one end and a piece of thermalite igniter at the other end. The visco end is obviously where ignition fire is applied and allows the prudent person some time to retire to a safe distance before fire is passed to the fast burning sticky match. The other end with the ignitercord or black match is expected to hold the ignition fire in the vicinity of the stars for a long enough time to ignite them. The flash flame of sticky match alone might not reliably ignite the stars in the mine. A note of caution is in order at this point. If you are planning to load a lot of



these mines into a rack of mortars, the sticky match leader fuse is not the best idea. In this case, one should use a leader of quick match because it is much less vulnerable to accidental ignition from sparks from a nearby mortar which has fired its contents skyward.

To make a simple star bag, a small cup is used as a former. A 10 inch square piece of tissue paper is stuffed into the cup as shown. The thermalite end of the sticky match is placed in the cup and 100 grams of your favorite stars are added. It's a good idea to bend the piece of thermalite into an "L" so it won't poke a hole in the bottom of the star bag.



Now the edges of the tissue paper are drawn up around the fuse and secured with a wrap of tape. The tape should keep the fuse from being pulled out of the star bag.



Finally, approximately 24 grams of good quality lift powder is placed in the bottom of the mine bag. I use homemanufactured black powder that has been corned into 4 to 10 mesh grains as an equivalent to 2FA commercial powder. Depending upon the quality of your lift powder, the amount used may need to be adjusted. The star bag assembly is placed into the mine bag on top of the lift powder. The concept, here, is that this method of assembly encourages good star ignition because the stars begin to burn for a short time before the lift powder is ignited by them and ejects them from the mortar. The final step is to close the top end of the bag with some manner of folding and taping. The fastidious craftsman will want to make a few pleats and tape it closed neatly. The less fussy person may just scrunch the top around the



fuse and put a wrap of tape around it. To each his own.

If you plan to make a lot of different kinds of mines with various kinds of stars in them, you will be well advised to use a marker to label your mines. It's a little embarrassing to announce to your audience that the next mine will be a glitter mine with red strobes for accent and upon lighting it, the mine turns out to be blue to green color changers. These 3 inch mines will put up a large column of stars to a height of about 80 feet.

Super Sparklers

Sparklers are one of the few fireworks items that are still legal in most places in the U.S. They are safer than most fireworks and reasonably easy to make. The sparkler project described here is really more like a large hand-held silver lance, but the function is still pretty much the same as the good old conventional sparkler. These will give the user a long lasting, beautiful silvery white fire and they are almost foolproof to make. The project requires the making of minimum tooling so I think it fits best here in the projects section.



First, a reinforcing sleeve is made from an 8.5 inch length of 3/4 inch CPVC. This pipe has an inside diameter of 11/16 inches even though its name implies that it should be 3/4 inches. A coupler is glued to one end to act as a crude funnel for adding the sparkler comp. Now take a coupler for 1/2 inch CPVC and hot glue it to a handle stick as in the picture. This is your high tech scoop.



The next step is to make a simple rammer from a 12 inch length of 5/8 inch diameter dowel. Sand it to remove any rough edges and imperfections and seal it with some kind of sealer. If your not a perfectionist, you don't even need to bother with the sanding and sealing. This ram will be quite loose in the tube so precision is not a major concern.

The composition mix comes from the Desert Blast formula for a 90 second waterfall. The list of chemicals follows:



- Potassium perchlorate
 50 parts
- Aluminum, bright15 parts
- Aluminum, 50-150 mesh, granular.....35 parts
- Dextrin.....+8 parts

This mix, when dry, is similar to a very slow flash. It should be treated with due respect, but no special mixing procedures are required. Enough water is added to just barely activate the dextrin. This means it will just stick together when squeezed, but is still quite crumbly and loose.

Now a common piece of 8.5 by 11 inch copy paper is rolled around the rammer dowel to form a tube 8.5 inches long. The dowel, with the paper rolled around it, is inserted into the sleeve tube and the paper is released. The dowel is removed and the sleeve tube is tapped and bounced a few times so that the natural spring in the paper will cause it to expand to fit snugly inside the sleeve. Next, the paper tube is pulled about half way out of the sleeve, just enough to get some glue under the free end of the rolled up paper tube. The paper is then pushed back into place inside the sleeve.



An end plug can be made by ramming about 1/2 inch of bentonite clay into the bottom of the tube. A better alternative is a paper end plug from Skylighter (item #198), but the drawback is that you have to buy 500 of them at a time. That would be enough to last me about 49 years. I suppose you could make your own paper end plug, but I'm too lazy to even consider that option.

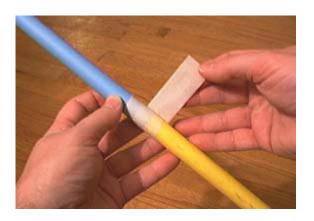
Once the end plug is secure, it's time to start charging the tube with the moistened sparkler mix. The scoop is first filled and then dumped into the end of the sleeve with the coupler on it. The scoop will fit inside the coupler and prevent any spillage as it is gently tapped a few times to encourage the mix to fall out into the paper tube.





Then the newly added composition is compacted by insertion of the wooden rammer. It may be rammed a few times by hand pressure or tapped a few time with a light mallet. Extreme pressure is not necessary because the dextrin binder will do the job of holding everything together just fine. This cycle is repeated until the tube is full to within 1/16 inch from the end of the paper tube. Then the loaded tube is pushed out of the sleeve with the aid of the rammer. At this point the filled tube will still have an unsecured paper flap which will need to be glued down to keep it from unraveling with handling.

The above procedure is repeated exactly as above, with one exception. No end plug is placed in the bottom. Just start right out filling the tube with the moistened sparkler comp. This is easily done by holding the end of the sleeve against the surface of your work table as you add the first charge. After ramming, the composition will stay securely in the tube without an end plug. The remainder of the tube is now charged to within 1/2 inch of the top. At this point, you have two charged tubes of sparkler mix whose paper walls are beginning to feel a little bit damp. They are somewhat delicate until they dry out and





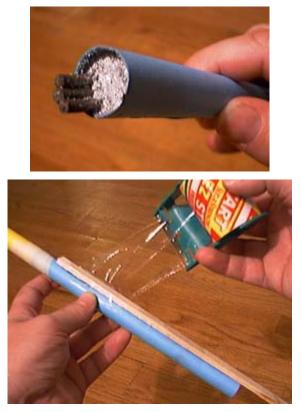
become hard. This will take at least three days, so be patient and set them aside while they dry.

When dry and hard, the tubes are ready for joining and mounting on a stick. The 1/16 inch cavity in the end of one of your charged tubes must be filled with a joiner mix that is sticky enough to adhere to the ends of both tubes. I use a little sparkler mix which has been moistened with 10% nitrocellulose lacquer to make a tacky paste. This will assure that the first tube will ignite the second tube before it burns out. This end is butted up against the end of the other tube where the sparkler composition is flush with the end. The ends of the tubes are held tightly together with a turn of wide masking or packing tape.

These sparklers are quite difficult to ignite unless you have a good igniter system to get them going. I can offer several alternatives which work very well. The first one uses what I call my universal igniter mix. It was given to me by Jim Farrell. Here is the list of chemicals:

- Strontium Nitrate.....50 parts
- Parlon.....18 parts
- Potassium Perchlorate......8 parts
- Magnalium, 150-200 mesh......12 parts
- Charcoal, airfloat.....5
 parts
- Sulfur.....5 parts
- Red Gum.....2 parts

A small amount of this dry powder is placed in a small paper cup. A few drops of acetone is added and stirred until a thick slurry is obtained. Then the stirring stick is used to dab some of the slurry on the end of the sparkler tube. The slurry will be very sticky and stringy because the acetone will partially dissolve the parlon in the mix. I like to poke and stir the sludge to make lots of strings and fuzzy projections instead of a smooth surfaced blob. This will make the igniter mix very easy to ignite when it all dries. This ignition method is also pleasing because it burns with a nice bright red color.



The other ignition method involves the use of a few short lengths of home-made thermalite ignitercord. In this case, two or three lengths of thermalite, cut to a length of 3/4 inches, are placed in the recess of the sparkler tube. Then the recess is filled with some of the joiner paste mentioned above to hold the thermalite in place. When finished, the thermalite will protrude about 1/4 inch out of the sparkler tube.

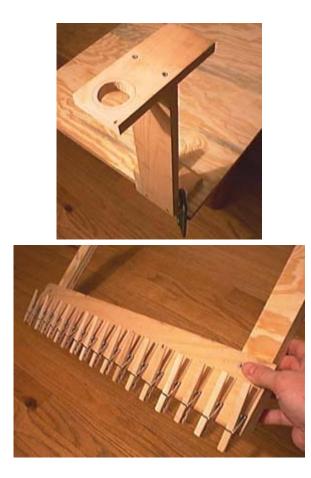
The last step is to attach the sparkler tube to a suitable stick for a handle. The final product will look much like a stick rocket except that the ignition end will be pointing up instead of down. I like to use a generous bead of hot glue augmented by 2 inch wide packing tape to attach the handle. The stick will be mostly consumed by the hot flame of the sparkler composition. If you prefer a sturdier, reusable option, a three foot length of 1/4 inch steel rod with a wooden handle is a good alternative. However, as with commercial sparklers which use a wire core, care must be taken to avoid burns from the red hot metal after the sparkler has burned out.

These "super sparklers" are very pleasing for those of you who like your creations to last a little longer than usual. They will give you nearly three minutes of enjoyment provided you don't wave them over your head. They will spit out long lasting, white hot sparks that will fall to the ground burning. Most of us don't enjoy hot, burning sparks landing on our heads and burning clear to the skull. I also would counsel against using these in a field where dry grass or brush could ignite from the falling sparks. Finally, I will share with you my fantasy about these "super sparklers". The next time I'm at a neighborhood gathering for the 4th of July and somebody pulls out their wimpy commercial sparklers, I imagine myself using Crocodile Dundee's line. "That's not a sparkler.....(I whip out my super sparkler)...Now THAT'S a sparkler!!"

Thermalite Equivalent Fuse

The word "thermalite" has come to be widely used in the pyrotechnics community as a generic term referring to a specific kind of fuse or ignitercord. The commercial version burns very hot and is therefore useful for initiating hard to ignite compositions. One very common usage is as an igniter in amateur composite rocket motors. The fuse comes with external wrappings of nichrome wire which can be used to perform electrical ignition. Sources for thermalite are increasingly hard to come by and purchasing it by mail will usually require permits and licenses. Thus, the need for producing a suitable home-made equivalent has never been greater. The method presented here represents my own adaptation of the method described in a publication entitled "Homemade Imitation Thermalite Ignitercord" by Firefox Enterprises, Inc. This project illustrates the production of only one of the many varieties proposed in the Firefox publication and does not begin to offer the full wealth of information contained therein. Various combinations of binders and chemicals can be used to produce burn rates ranging from 5 seconds per inch to slightly more than one second per inch. Since my most common use of thermalite is for cross-matching time fuse, I chose to illustrate the fastest burning and easiest to ignite variety.

WARNING!! This project uses chlorates and finely powdered magnesium. The dry composition is very sensitive and must be handled with proper care. This procedure should only be attempted by those whose knowledge and experience will minimize the risks of handling these materials.



There are a few pieces of minor tooling that enhance the process of making thermalite, but they are very simple to make. First, a pedestal to hold the batter cup is nice because it frees up the hand that normally would have to hold it. This one can be clamped to the edge of a work bench so that the batter cup is held out over the floor. It is made of pieces of 1 x 4, one of which has a round hole in it for the cup.

Here, I have made a drying rack by using hot glue to fasten 18 clothes pins to another piece of 1 x 4. This is hung from the ceiling of my shop so that fairly long lengths of fuse may be suspended from it if desired.



A binder for the fuse composition is made by mixing the following: (parts by weight)

- nitrocellulose lacquer(10%)...... 25 parts
- dibutyl phthalate(plasticizer)..... 10 parts
- acetone.....
 18 parts

The vinyl resin and plasticizer are available from Firefox. Thirteen bucks will buy enough of both to make more fuse than most people will use in a lifetime. You can mix up a lot of the binder at once and store it in a jar for whenever it's needed.

Now the dry composition is prepared. This is where a good deal of caution and proper handling becomes imperative. The list of chemical ingredients is:

- potassium perchlorate...... 37 parts

- magnesium, 200-325 mesh...... 15 parts
- red iron oxide, ferric......5 parts
- aluminum, -325 mesh,
- flake....... 3 parts
 sodium bicarbonate(additional)..... 1 part

The magnesium should have been treated with potassium dichromate or coated with linseed oil prior to using it in this composition. This will make it less likely to react with any water present in the acetone. Another alternative is to use molecular sieves to dry your acetone. The potassium perchlorate, potassium chlorate and





iron oxide are screened together first. Make sure a screen which has never been used with sulfur is chosen for the screening. In a separate mixing cup, the remainder of the dry ingredients are weighed and stirred together. Finally, the two compounds are mixed together using a gentle method called the diaper method, shown in this picture. The two piles are placed on a large piece of paper, such as newspaper, and mixed by picking up alternating corners to gently roll the powders over each other until thoroughly mixed.

Prior to mixing the binder with the dry powder, the core wires should be prepared. For a typical batch, I cut 18 lengths of 26 gauge copper wire to a length of 19 inches. The wire is then "roughed" by pulling it through my pinched fingertips which are holding a piece of folded sandpaper. This gives the wire surface enough texture to allow the batter to stick to it. Now, 25 grams of dry mix and 17 grams of binder are placed in a 5 ounce paper cup and stirred to make a batter about as thick a pancake batter. The cup is placed in the "batter pedestal" and a small hole is poked in the bottom. The batter should be thick enough that none will drip out of this hole. This "first dip" is accomplished by pushing the wire up through the hole until about an inch of it protrudes from the top surface of the batter. A tissue is used to clean the batter from the top 1/2 inch of the wire. Then the wire is grabbed from the top and slowly pulled the remainder of the way through the batter. After the first dip, the batter diameter will be guite small at about 1/16 of an inch. The wire is then clipped into the drying rack and the procedure is repeated for the remainder of the wires. They will be ready for the second dip in a few hours.





The second dip is identical to the first, except that the hole in the batter cup may need to be widened slightly to allow the thickened first dip wires to go through. The batter can be slightly thicker for the second dip so that the coating will be thicker also. Pulling speed will also affect the finished thickness somewhat. Very slow pull speed allows some of the batter to drain off, yielding a thinner coating. Both of these factors can be varied to adjust the final diameter between the range of 1/8 inch to 3/16 inches. It may be necessary to add a few drops of acetone and stir the batter occasionally because this solvent evaporates so quickly. Again, the dipped wires are clipped to the drying rack until they are completely dry. This will take about 6 to 8 hours.

When completely dry, I cut the finished igniter cord into 6 inch lengths so they can be easily stored. The finished product is firm, but flexible. It is very durable because the composition will not flake off easily when the cord is bent. This stuff is quite water proof and burns with a pleasing and loud hiss. I have found a plethora of uses for this marvelous improvisation for thermalite. Among them are:

- It can be used as a substitute for visco in most cases, although the slower speed variety is better for this purpose. At 3 cents a foot for materials cost, it's less expensive, too.
- It is a very good replacement for black match when used for cross-matching.
- I use a small length of it in the nozzle of fountains when I want to ignite many at once with sticky match. The same concept is used to ignite girandola drivers and most other forms of black powder rockets.
- Whenever I use sticky match to replace quick match for mine and shell leaders, I put a

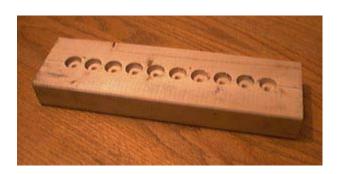
piece of the thermalite at the end of the match to assure ignition of the lift powder.

 I haven't tried this yet, but I think there is a good possibility that short lengths of this cord could be used to make go-getter inserts in a shell. A few wraps of masking tape with a little bit of one end left exposed, would create very energetic little rockets. Even unwrapped lengths will fly all over when lit if they are not attached to something.

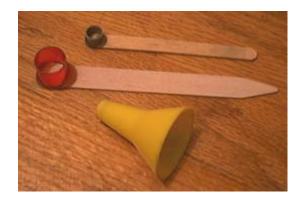
I'll close this project page with a few comments about the Firefox booklet. If you are seriously contemplating this project, I highly recommend that you purchase the booklet. It contains two different dry formulations and two binder solutions. It will tell you how to make this thermalite equivalent in a variety of ways to achieve a wide range of burning speeds. I have not included all this information in my project description because Firefox deserves to benefit from their development efforts and publication of this material.

Roman Candles

Roman candles have been around for years and are among the most popular of traditional fireworks effects. I like them because they are relatively easy to make and because they offer a lot of room for creative expression in the choice and combination of stars that can be used. This project describes a fairly small scale implementation of the concept to build a class of effects with names like the "dancing curtain of fire" and the "sparkling daisy."



This project requires the building of 20 candles which use 1/2 inch I.D. tubes. When making so many identical items, it helps to make a little tooling that lends itself to high efficiency mass production.



Otherwise, you might expire from the shear boredom of repeating each step an endless number of times. First, a simple stand is made from a piece of scrap 2 by 4 by drilling 10 holes in a row to hold the tubes in a vertical position.

The remainder of the tooling consists of a specialized funnel, a lift charge scoop, a delay composition scoop and a few rammers. The funnel is chosen to fit snugly into the tubes and be able to remain in place without falling out. The mouth of the funnel has been greatly reduced to make it less cumbersome. The lift powder scoop may need to be tailored to the strength of your powder, but this one measures slightly less than 1/8 teaspoon of volume. It was made using a short length of plastic tubing scavenged from the snap-on cover of a BIC pen. This was then hot glued to a common popsicle stick. The delay composition scoop measures roughly 3/4 teaspoon of volume. I try to use as little delay comp as possible to



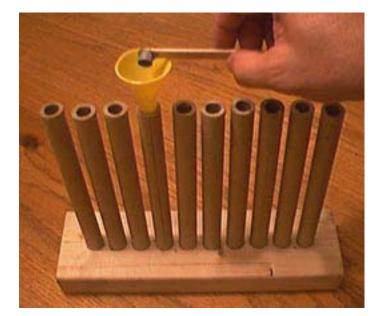
prevent the fire from passing too quickly between star shots. This allows the loading of more stars per candle, but if too little is used to form an adequate seal, the candle can end up sounding like a machine gun. This effect may be worth exploring if you want to put up a lot of stars in a hurry, but for candles, the desire is to have enough delay so that a new star is ejected approximately when the previous one burns out.

The tooling is completed by making a few rammers. The main candle rammer is made by starting with an 11 inch length of 1/2 inch hardwood dowel that fits snugly inside the candle tubes. Any of several means is used to sand down the surface of the dowel until the "handle" portion of the rammer measures about 7/16 inches in outside diameter. Only the final 1/2 inch of the ramming end is left at its original diameter. This rammer will now be much easier to insert and retract from the candle



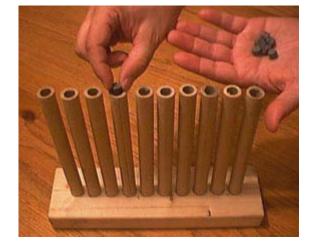
tubes. I accomplish this task by placing the rammer dowel into the chuck of my drill press and rotate it at slow speed against a sanding block. The fuse rammer is made by cutting a 4 inch length of the same dowel material. A fuse hole is drilled into the end of the dowel to a depth of about 1 1/4 inches as shown in the photo. This is accomplished by inserting the dowel into a 1/2 inch hole drilled into a piece of scrap wood until the dowel end is flush with the surface of the wood scrap. The scrap is then clamped to the deck of a drill press with the dowel protruding downward and the fuse hole is drilled along the edge of the dowel as illustrated.

This project uses tubes that are 1/2 inch ID and 8 inches long. Each of them needs an end plug of clay before the flammable contents can be added. Many combinations of clay and grog are possible, but I have settled on a mix that works for all of my end plug and rocket nozzle



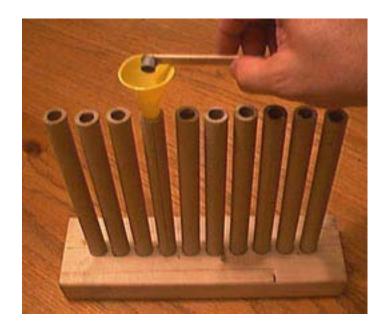
needs. It consists of 50% fine bentonite clay powder and 50% kyanite (-48 mesh) from the local pottery supply store. This mix is then treated with an additional 5% of toilet bowl wax dissolved in Coleman fuel. Using the delay composition scoop, a scoop full of this clay mix is then rammed into the end of each candle to form a very uniform and solidly sealed end plug.

Next, 10 of the plugged candle tubes are inserted into the mass production stand and the funnel is placed into the top of the first one. The funnel has the duel purpose of aiding in the quick loading of the powders into the tubes and serving as a place marker to keep track of which tube needs to be charged at what time. Without this little mental aid, it's very easy to loose your place. The first lift charge is placed in each tube with the following cyclical sequence of motions: load the scoop, dump the scoop into the funnel, move the funnel to the next tube in line. For

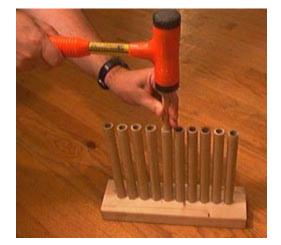


this lift powder, I used homemanufactured 4FA equivalent black powder corned at -20 to +40 mesh.

Now a star is dropped into each tube. I count out exactly 10 from the star cannister and hold them all in my hand at once while I drop them into the tubes, one at a time. This way, I never have to take my eyes away from the tubes and risk loosing my place. Probably the best suited kind of star to use for roman candles is the kind that is made with the use of a star plate because they end up being cylindrical in shape. The stars shown in this picture are 3/8 inch "Improved Snowball" stars that were made using a plexiglass star plate. They have enough clearance in the candle tube to easily drop all the way to the bottom without getting stuck. Other kinds of stars will work nearly as well. I have used round stars and even cubical cut stars with good luck.



Now, another scoop of lift powder is added to each tube with the repeated cycle of motions described above. The base board is then tapped a few times to encourage the powder to settle down around the sides of each star. The amount of lift powder added may vary, depending on the geometry of the stars that are used. The idea is to fill all the space around the star so that the star is completely encased in lift powder. The lift powder at the sides of the star will quickly pass the fire down to the lift powder underneath the star which propels the burning star out of the tube. Some folks may use a different grain size powder or a different composition for the pass fire function, but I use the same for both functions to simplify the assembly process.



The next step is to add a delay composition on top of each star. The delay comp scoop is used to do this in exactly the same manner that the lift powder was added, with the funnel acting as a place marker. After the delay composition has been added, it must be compacted by ramming to seal the tube and prevent fire from prematurely reaching the next star. This needs to be done consistently and uniformly by using the same number of ramming blows with equal force each time. I use 4 blows with a 16 oz. dead blow hammer using only the wrist as a pivot point. The wooden rammer is then lifted, rotated 1/2 turn and pushed down again. Four more wrist blows of the hammer complete the compaction of the delay composition.

Perhaps, before proceeding much further, it would be wise to describe the delay composition in a little more detail. It is simply a green mix of black powder ingredients which uses an excess of charcoal. Below is a table showing a few examples of candle compositions from published literature. The numbers have been converted from parts to percent for easier comparison.

	Davis	Weingart	Lancaster
KNO3	54	50	50
charcoal	33 (mixed mesh)	30 (fine or AF)	22 (50% 36 mesh. 50% 80 mesh)

sulfur	11	17	6
dextrin	2	3	
Meal D			22

A green mix of black powder is one which has been screened, stirred or shaken together, but no processing has been done to improve the intimate incorporation of the chemicals. If the individual elements of the mix are fairly fine powders to start with, the mixture will act like a fluid during ramming. The result is that a jet of powder may squirt past the rammer and out of the tube either when the rammer is inserted or when the rammer is struck with a hammer. To avoid this kind of messy behavior, it is recommended that the green mix be treated so that it is converted into coarser granules that will not act like a fluid. This is why some of the above candle compositions contain dextrin as a binder. The treatment is accomplished by dampening the mix with water until it just holds together when squeezed into a ball. The lump is grated through a window screen onto paper to form granules which are then allowed to dry. These granules are fairly soft and will still crush and compact easily when rammed, but they are now much less messy to work with when making the candles for this project. Another consideration is the kind of charcoal that is used. The Davis composition calls for a mixture of mesh sizes, some coarse and some fine. This will produce a better spray of orange sparks while the delay composition is burning. The Lancaster version uses no fine charcoal at all, but compensates by using some meal D. I prefer this one because it can be used without the granulation treatment.

Paper tube
Delay composition
Cylindrical star
Pass fire BP
Lift BP
Clay end plug

At this point, the internal structure of each candle should look like the illustration shown here. One cycle of loading lift BP, a star, pass fire BP and delay composition has been completed for each candle in the batch of 10. This cycle is repeated until each candle contains 8 stars. This is where your endurance and concentration will be tested. Murphy's Law asserts that it is during this phase of construction that the phone always rings or your kids will ask for the car keys or your honey wanders by in her bikini. Any of these distractions can



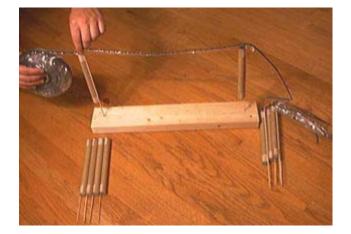
seriously alter the proper order of your candle assembly line, but the truly focused pyrotechnical artist will be undeterred.

The next task is to secure a short length of fuse into the end of each candle. Black match will work well, but I like to use my own igniter fuse for this purpose. Each piece of fuse is cut to a length of 1 1/4 inches. Another scoop of delay comp is added to each candle and a piece of fuse is inserted against the inside surface of each candle tube until about 5/8 to 3/4 inches protrudes from the end. The candle comp is then compacted around the base of the fuse by using the fuse ram as shown. Now, in order to assure 100% ignition, the fuses can be primed with a little dab of Meal D bound with nitrocellulose lacquer. The prime is completed by sprinkling a little dry Meal D on the dab of wet primer goop. At this point, half of the candles have been completed. Now, it's time for a cold soda before the



above process is repeated all over again to make the second batch of candles.

All that remains to complete the candle construction is to attach a bamboo skewer stick to each one with the blunt end of the skewer stick extending above the fused end of the candle by about the same distance as the fuse. If my verbal description has confused you, the picture should make it much clearer. A short piece of masking tape at the top and bottom does the job nicely. The idea, here, is to give a lot of rigid support to the fuse so that when the candles are matched together, they can take considerable handling abuse without dislodging the fuse from the end of the candle.



The choice must now be made whether to match the candles together or wait until the candles are arranged at the display site and do the matching at the site. I prefer to match them all together during the construction phase and then bundle the candles all together for temporary storage until show time. This reduces setup time before the show and also assures a more accurate spacing of the candles. The matching is accomplished by using a board with two holes for the skewers placed at the desired distance between candles. An 18 inch spread between candles will yield a string of candles that is 30 feet long. Two candles are mounted in the skewer holes and sticky match is strung between them from a spool. The sticky part of the match is clamped over both the fuse and the skewer stub. Now, since the candle string is being built to the left, both of the matched candles are removed from the stand and shifted



to the right. The left candle which is attached to the sticky match is mounted in the right hole and the right candle is laid down on the table. A new candle is mounted in the left hole and the sticky match is unrolled from the spool to reach the new candle. This cycle is repeated until all the candles are matched.

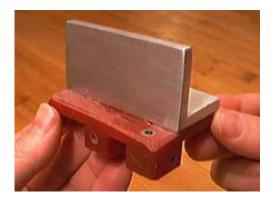
Here we see the finished piece. It has been strapped together with masking tape for easy storage and handling until show time. When setting up the candles for display, there are many options to choose from. The skewers are simply pushed into the ground to arrange the candles in a variety of ways. The "dancing curtain of fire" is achieved with a straight line of candles all positioned vertically. The "sparkling daisy" is accomplished with a circle of candles aimed outward at about 45 degrees. Another of my favorites is a straight line with alternating candles aiming forward and backward. The forward candles fire green stars

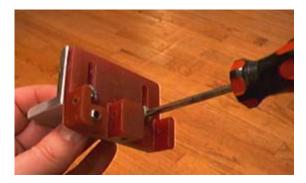
and the backward candles fire red stars. With different kinds of stars and different arrangements, the possibilities are almost endless. I'm still working on an arrangement I will designate as the "Screaming Revenge of Montezuma". Any suggestions?

Stinger Missiles

The name "stinger missile" seems to have become fairly common among pyro hobbyists to refer to the class of rockets which are spin stabilized. (The more accurate terminology is the same as the popular military weapon, but I had to change all references to this name because the terrorists were far too interested in this page.) This means that the usual efforts to assure a predictable flight path of a rocket, which include body fins or a guide stick, can all be dispensed with. Consequently, the spin stabilized rocket is extremely easy to make. This is what makes them so much fun. Unlike a girandola project, these little jewels can be made in a few minutes and launched immediately. It's a great fix for the smoke addicted pyro who often needs to throw something together guickly. The methods presented here closely follow those first described by Warren Klofkorn some 10 years ago. His article appears in "The Best of AFN II" on page 62 and has become the standard reference for stinger missile construction. A description of my personal experience with his instructions and a few other innovations, hints and tips are included here in the hope that they might make your experience more enjoyable.



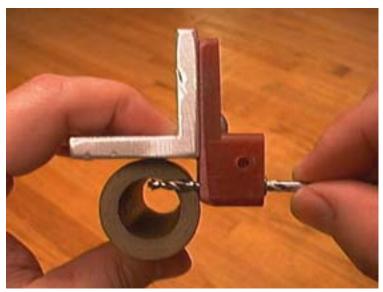




Tooling is usually the first consideration of any new pyro project. Since the tooling for stingers is fairly simple, it doesn't cost much to buy it from professional sources. I purchased a tooling kit for the 3/4 inch stingers from Skylighter for the bargain price of \$44.95 US. Shown in this picture, a machined aluminum spindle is mounted in a ramming base and held in place with a bolt through the bottom. The rammers consist of an aluminum rod with a hole in it for pressing the black powder fuel around the spindle and a solid one for pressing the fuel and delay composition above the spindle.

This is a close-up of the jig used to position the side vent hole in the stinger body tube. This hole is used to create tangential thrust which will cause the rocket to spin as it flies. The angular momentum of the spinning rocket is what stabilizes it instead of relying upon positioning the center of pressure behind the center of gravity, as accomplished by fins or sticks. This jig helps to accurately position the vent hole to consistently achieve a good spin. The desired location of this vent hole is just above the clay nozzle and in a direction that is at a tangent to the inside surface of the tube. This jig is one of an older generation and may look a little different from the present Skylighter product, but the function is identical.

To adjust the jig for the size of stinger you plan to make, you must first loosen the two screws until they allow the guide hole plate to slide relative to the angle piece. Adjust the screws to be slightly snug so that the two jig pieces aren't overly floppy, but will slide with a little effort.





Now get a piece of stinger tubing and hold it against the jig as shown. Place the 9/64 drill bit in the guide hole and check the alignment as illustrated in the picture. The drill bit should be positioned so that its side flutes are even with the inside wall of the tube. If this verbal description is not clear, just look at the picture. As they say, it's worth a thousand words. Now, if your alignment isn't correct, just slide the jig pieces until it is and then tighten the screws. This alignment will assure that, when drilling the side vent hole, the drill bit will emerge at the right place on the inside surface of the tube. With the vent hole aligned correctly, you will achieve the best thrust angle to maximize spin and stability. Be sure that your adjustment screws are in the same places in the two slots, assuring that the two jig pieces are parallel to each other. Another good tip to use at this point is to put a small piece of tape on the drill bit to mark the proper depth of insertion into the guide hole. The proper depth is also shown in the picture. If the drill bit is allowed to go any further into the guide hole, it will begin to drill into the opposite wall of the tube, causing undesirable weakening at that point. With this done, the jig set up is complete and you're ready to get your hands dirty and have some real pyro fun.

Construction of the stinger starts by preparing the body tube. A typical 1 pound rocket tube may be used. The Skylighter TU1068 is a good example. It measures 3/4 inch ID, 1 1/4 inch OD and 7 1/2 inches long. You can save even more if you buy the longer TU1065 from which you can cut as many as 9 stinger tubes. Either way, a tube must be cut to a length that depends on what heading is planned for the payload of the rocket. Cutting these heavy tubes is best accomplished by using a table or radial arm saw because a clean, square end is desirable. A length of 3 inches is typical for a rocket which contains some colored star composition for delay and some flash powder for a salute finish. Another option is to add a header extension filled with stars and some burst composition. When this option is chosen, the body tube can be cut a little shorter, enabling three stingers to be made from a single 1 pound rocket tube. The construction of these headers will be covered later.





With the tube cut to the desired length, it is placed over the spindle on the spindle base and a carefully measured amount of nozzle clay is poured into the tube. A small funnel of some sort, as shown on the floor in the picture, is very helpful in accomplishing this. Klofkorn's original article advocated the use of 4.3 cc of powdered Hawthorne Bond clay for the rocket nozzle. I use a 60%/40% mix of bentonite and kyanite treated with an additional 5% of toilet seal wax dissolved in Coleman fuel. Instead of using a volume measurement for the nozzle clay, I recommend that you use a weight measurement so that a consistent nozzle length is achieved. The importance of doing this will become evident shortly. Stay tuned. If you are not using a hydraulic press, the nozzle clay is compacted by administering about a dozen firm blows with a mallet of some sort, as shown in this picture.

Before drilling the side vent hole in the body tube, a mark must be made on the outside of the tube to indicate where the top of the nozzle is located. Start by applying a piece of masking tape to the rammer so a mark can be easily made on it. Then place the rammer in the body tube until it seats against the nozzle. Now make a mark on the masking tape, as shown. Of course, if you were really on the ball, you could do this right after you finished ramming the nozzle clay, in the step above.



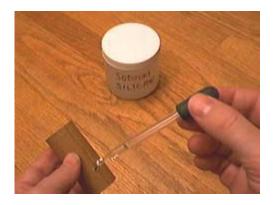
Next, remove the rammer and hold it against the outside of the tube with the mark you just made even with the top of the tube. Make a mark on the body tube at the bottom of the rammer. This mark should now indicate where the top of the nozzle is inside the tube.

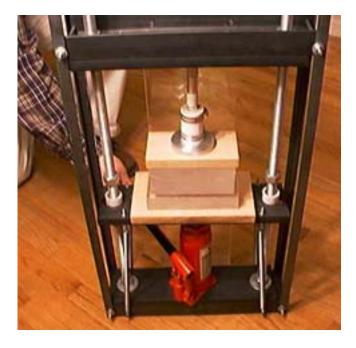


Now the tube is held in the drilling jig, as shown. The guide hole should be located so that the side vent hole will be drilled just above the nozzle. In case you haven't figured it out, you'll probably have to remove the tube from the spindle base to drill the side vent hole.



With the body tube properly positioned in the drilling jig, the hole is slowly drilled with a hand drill, taking care to firmly grip the tube in the jig so that it doesn't move. Again, note the piece of tape on the drill bit, which indicates the proper depth for the drill bit in the guide hole. Now pay close attention. Here comes the nifty tip you've been waiting for. Once the location of the top of the nozzle has been established, it should be measured and preserved in your notebook. This measurement can be used in all future stingers with the assumption that it will always be accurate. The assumption is a safe one to make if your nozzles are always made the same way with exactly the same compression and same amount of clay. The

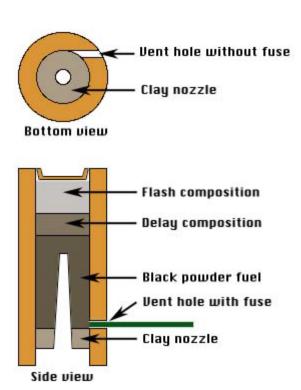




significance is that the side vent hole can be drilled before the nozzle is rammed, eliminating the need to remove the tube from the spindle to locate the top of the nozzle and drill the hole after nozzle ramming. It's a nice little time savings.

The vent hole can be made to be much more impervious to hot exhaust gasses by treating it with a few drops of sodium silicate solution, as shown in this picture. An eye dropper is used to put the silicate into the hole. A toothpick or small nail is then used to spread it around in the hole and prevent blockage or constriction of the hole. Some of my impatient pyro friends skip this step to avoid waiting the required 20 minutes for the silicate to dry in the vent hole. Their stingers still seem to fly just fine, albeit possibly not quite as high.

This picture illustrates the use of a typical rocket press to form the nozzle and load the black powder fuel. When a hydraulic press is used instead of a mallet, a reinforcing sleeve is a good idea to avoid deforming the rocket tube. Which ever method is used to load the black powder fuel, a little scoop, as shown in the hand ramming picture above, is handy for measuring out the fuel for each pressed increment. I made mine by hot gluing the bottom section of a film canister to a small garden marker stick. The black powder fuel must be compacted in the tube in about 4 or 5 increments, each of which should be no longer than the inside diameter of your stinger tube. For the black powder fuel. I use the same milled meal that I use to make a good lift powder. It contains willow charcoal to make a very hot rocket fuel. This fuel would be too hot for a standard 1 pound rocket, but for stingers it works very well because the rocket core is considerably shorter. I have notice, however, that in the case of the larger 3 pound stingers, my homemade black powder is a little too hot. I experienced a few explosions immediately upon ignition until I cooled the fuel down a little with a few percent of mineral oil. As with most black powder based rockets, you may need to experiment a little to dial in the proper burn rate for your stingers.





After the rocket has been charged with its black powder propellant, some delay composition should be loaded above it to allow the stinger to reach its apogee. Otherwise, your stingers will activate their payloads at very low altitudes because the actual thrust burn only lasts about 1 second. The following green star composition is suggested by Klofkorn as a safe and compatible delay element:

- Barium
 Nitrate.....28.3%
- Potassium
 Perchlorate.....47.2%
- Parlon......4.7%
- Red Gum.....14.2%
 - Soluble glutinous rice starch......5.6%

Somewhere between 6cc and 9cc of this composition, damped with a sparing amount of alcohol, is pressed into the top of the tube using moderate pressure only. It is a good idea to give this delay composition a little drying time before adding the final heading to the rocket. The diagram at the left shows the internal structure of the missiles after a heading of flash powder has been added. There is nothing sacred about this particular way of making a delay. Dextrin can be substituted for the rice starch or a totally different delay composition can be used. I am a little partial to some of the glitter formulas, myself, such as Winokur #39.

Now we are ready to talk about the various heading options for our stingers. After all, what's the point of making a rocket that just spins as it flies if it doesn't do something cool at the end of its flight? The easiest heading is 3 cc of flash powder in the remaining cavity of the stinger tube. This is finished with a 3/4 inch end cap that just touches the flash powder enough to keep it from shifting during the spinning ascent. An easy shell header with stars can be constructed using a 1 1/2 inch length of paper tube whose ID is 1 1/4 inches. This tube is glued to the stinger tube with a 1/2inch overlap. The expanded cavity now has more room to accommodate a larger payload of stars and burst. The payload





space needs to be filled completely and firmly packed so that no asymmetries can be created when the stinger spins. The cavity can be closed in a variety of ways. A typical end plug or cap will do the trick, but if you want to maximize your payload space, a molded nose cone can be used. The nose cone shown in the picture is molded from craft paper pulp bound with CMC binder. An example of each of these header options is shown in the picture. Again, whatever header is chosen, care must be taken to avoid asymmetries, or your stingers will wobble all over the sky.

Now a fuse is added to the side vent hole. A 1/8 inch drill bit (1/64th smaller than the one used to drill the hole in the tube to start with) is inserted into the hole and twisted gently by hand to open a small cavity in the black powder fuel grain. A glob of Meal D wetted with nitrocellulose lacquer is placed on the end of a 3 inch length of visco fuse. The globbed end is inserted into the vent hole as far as it will go. The lacguer will dry shortly and secure the fuse in place. I don't bother to bend it against the tube wall and affix it with tape, as recommended by Klofkorn. This practice has damaged the somewhat brittle visco and has caused failure of ignition on some of my stingers. If you use a more flexible fuse, this may still be a good idea to make the fuse more secure during storage and transport.

A little bit of added stability at lift off can be achieved by gluing a custom reinforcement to the business end of the stinger. This is accomplished by tracing a circle around a stinger tube on a piece of strong tissue paper. A notebook paper hole reinforcement is then glued to the center of the circle. The circle is cut out and glued to the nozzle end of the stinger as shown in the picture. The launch spindle will be inserted through the hole of the reinforcement at launch time. The reinforcement helps the stinger spin about its central axis without wobbling. Another possibility I have seen used for this purpose is a standard paper end plug with a hole punched in it. The end plug is not glued into place so it will easily be blown out when the stinger flies. These end plugs may usually be reused a few times before they become too badly charred.



The stinger missile requires a custom launch pin to support it prior to launch and during initial spin-up of the device. This can be as simple as a nail driven through a good sized piece of wood to give it a solid footing during launch. The last thing you want when these things start spinning is for the launch stand to tip over and send an angry stinger missile into your terrified audience. The nail is rounded at the end by a file to provide a good pivot point at the top of your stinger core. This picture shows a typical launch stand with two launch pins, one supporting a finished missile ready for launch. A little decorative paper has been added to give it a festive flair. All that remains is to light the fuse, retire to a safe distance and feel the rush these marvelous little rockets give to their creator and his audience.

Tips and suggestions for further enhancements:

- After a suggestion from Lindsay Greene, I tried adding 3% of 40-200 mesh spherical titanium to the black powder fuel. It creates a beautiful, cork screw trail of bright golden sparks as the stinger ascends. It is a very impressive effect with little extra effort. The only drawback is that the titanium causes a little extra wear on your tooling and launch spindle.
- Another possible time saver is to insert the fuse into the side vent hole before ramming the black powder. The powder will compress around the fuse and help secure it in place. Care should be taken not to insert the fuse too far, however, or it might shorten the spin-up time before the main stinger core ignites and sends it skyward.
- The launch spindle must be long enough to suspend the stinger above the launch base. If the bottom of the stinger is touching the wooden base, it will interfere with the stinger's ability to spin on the spindle.
- An exciting recent innovation is to use flying fish fuse in the header. A bundle of short lengths of this fuse will ignite to a make a swarm of little wigglies all over the sky. One end of each fuse is primed to aid ignition and the other end is coated to inhibit ignition. This special fuse can be purchased from Skylighter.

Clark's Giant Steel Fountain

Fireworks are so numerous and varied that they can be divided into

many different categories or classes. Each class has a piece that can be considered the king in the class. Of course, this is a very subjective judgment, but I take this occasion to proclaim my assertion that the king in the class of fountains is indisputably Clark's Giant Steel Fountain. The description of this awesome device first appeared many years ago in "The Chemistry of Powder & Explosives" by Tennyson L. Davis. Many have tried to make an embodiment of this device that lived up to its description, only to fail. Having experienced several such failures myself, this project became a kind of fireworks "holy grail" to me. Diligent pursuit of the goal has finally allowed me to achieve moderate success. I will attempt to allow others the supreme satisfaction of building one, too, by describing my methods of construction. As always, your mileage may vary and satisfaction is not guaranteed. Just remember that my advise is free and you get what you pay for.



The original description of this project calls for a paper tube with a 4 inch outside diameter, 2 inch inside diameter and 1 inch thick walls. This is required because of the tremendous pressures that must be withstood by the fountain. Until recently. this kind of paper tube could not be purchased, but you can now get them from Dawntreader Pyrotechnic Specialties. It is made by bonding one tube inside another to achieve the total wall



inch. If you purchase them separately, the outer tube can be reused and the inner tube is discarded after use. This will save you a few bucks if you are a penny pincher like me. Here you see a picture of the tube assembly at the right and the separate inner and outer tubes at the left. An even more thrifty approach can be achieved if you want to go to the effort of rolling your own tube. In the picture is shown a Skylighter tube with a 2 inch inside diameter and 1/8 inch thick walls. This is used as a mandrel over which is rolled a paper tube with a wall thickness of 3/8 inches for a total of 1/2 inches. This assembly is then bonded inside a common 3 inch paper mortar tube with 1/2 inch walls or a Dawntreader outer tube. The

thickness of 1



inner Skylighter sleeve is not glued in place, but is used as a replaceable liner. This way, your disposable material cost for a fountain is only about two bucks. The problem is that rolling an inner tube this large is no simple task. It must remain very round and uniform to fit perfectly inside the outer tube. I succeeded only after using a lathe to true up a tube wound with 60 pound craft paper and fiberglass resin. Since this fountain is made by compressing the composition inside the tube, a suitable ram must be made for the job. You can buy a premium quality, custom turned, hardwood ram from Dawntreader for about \$50. They also sell an economy version of the

wooden ram for about half that much.



Then we come to the penny pincher alternative, which I, of course, opted for. The picture shows an eighteen inch length of 1 1/2 inch black pipe with threads at one end only. Hardwood and plastic plugs are made with a lathe for the non threaded end and a tfitting with a threaded metal plug is used at the other end. The plugs with holes in the middle are for use with the spindle tooling pictured below while the flat bottomed, solid plug is used if you plan to drill out the core with a very big drill bit. If you are

fortunate enough to have access to a metal lathe, a spindle such as this one can be made to form the central core of the fountain. It consists of a stainless steel spindle which has an aluminum collar to align the paper tube. This spindle and collar are

then mounted to a ramming base of 3/4 inch aluminum plate. The spindle is designed to produce a core length of 12 inches, which is 2 inches longer than the core produced by the drilling procedure described below. A longer core length means more surface area is allowed to burn at once and a higher internal pressure will result. This translates to a higher plume of sparks during operation, but the risk is higher of a nozzle blowout or failure of the tube to contain the extra pressure. A dimensional drawing of this tooling can be seen below. The spindle puller is an essential part of this tooling because without it, the extraction of the spindle from the compressed clay and composition is almost impossible. If you belong to



the class of poor unfortunates that don't have access to machine tools, then you are left with the equally effective alternative of drilling out the core with a hand drill. The bad news is that you have to shell out \$22 for a 7/8 inch by 18 inch long drill bit called the "Naileater" at Home Depot. This method of making the fountain core is described and illustrated below. With the tooling and supplies gathered up, the project is begun by treating your steel filings with boiled linseed oil or paraffin. I purchased Skylighter iron borings (CH8160) and medium iron filings (CH8156) for this purpose. The borings are rather large, thin curls that need to be crushed a little to be usable. I did this with an old meat



grinder and then screened out the fines to yield +20 mesh chips. To this is added an equal weight of the medium filings screened for 20 to 40 mesh. This mixture is then coated with the linseed oil and sprinkled thinly on waxed paper to dry. It takes 4 or 5 days to dry, so you need to plan ahead. Mixing the fountain composition is fairly straightforward. If you plan to drill out the core of your fountain with the "Naileater". you will need a batch size of 1400 grams. If you use the spindle tooling, you can get away with a batch of 1050 grams, because the core material is not wasted. For the first case, 1000 grams of potassium nitrate is added to 200 grams of red gum and screened together several times to get an even mixture. Then

200 grams of the treated filings are folded into the mix by stirring. A good sized bucket or bowl with a lid will be needed for this mixing task. A spray bottle is then used to mist the mixture with solvent while stirring to dampen it. The Davis instructions call for a 50% mixture of water and alcohol, but I used pure alcohol to speed the drying time of this fountain. The consequence is that the mixture must be kept in a lidded container prior to and during the ramming stage or it will dry out in the bucket. Dry composition will not compress well and might lead to dangerous voids in the final fuel grain.



Ramming the fountain full of explosive composition can be an exhilarating experience if you're young and full of energy. Unfortunately, I'm not so I devised a different solution, but, for the rest of you, manual ramming is a viable method. First, a 1 1/2 inch plug of hardwood is placed in the nozzle end of the tube without any glue. It will be removed later and is only used to recess the nozzle to make room for a drilling guide. The tube is then positioned nose down in a big bucket which is filled with potato sized rocks. This bucket is then placed on a solid concrete floor for the ramming station. Three increments of 100 grams each of bentonite clay are rammed in the tube to form the nozzle, which

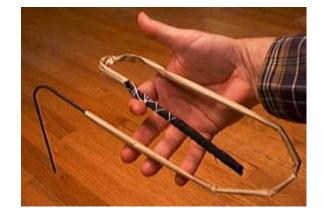
will occupy three inches of length in the tube. This is done by striking the ram with the biggest sledge hammer you can get your hands on. I used the splitting maul shown in the picture. If you use the metal ram, you must expect that the ramming could cause sparks from the two ferrous metals impacting each other. The safety minded person would make sure no loose composition is on top of the fountain tube. on the floor or anywhere near the ramming station. If the risk gives you the "willies", then you should buy a Dawntreader hardwood ram or consider the method shown below.



Not needing to prove my manhood by using the manual ramming practice mentioned above, I decided to modify my rocket press to give it enough vertical clearance to handle the task. Two more 2 foot long threaded rods were used to extend the 3 foot rods used in the original hydraulic press. A single nut seems to be strong enough to handle the forces of the press when used to join the 3/4 inch threaded rods together. Using the rocket press, the process of consolidating the fountain composition in the tube is safer, easier and will give you better compression. This alternative is a clear winner in my book.



After the 11 inch column of fountain composition and 3 inch end plug of clay have been rammed or pressed, you can immediately drill out the core with your "naileater" auger bit. If the spindle is used, a 13 inch column of composition is needed and you can, of course, skip the core drilling step. The core is drilled by removing the solid wood plug from the nozzle end and replacing it with one which has a 7/8 inch hole drilled in it to act as a drilling guide. A piece of tape is placed on the drill bit at 14 1/2 inches from the cutting edge at the tip. This marks the hole depth and sets the core length at 10 inches beyond the clay nozzle. The core is drilled with the tube clamped horizontally on the work bench with the nozzle end extending over the edge



a few inches. A tray is placed under the nozzle to catch the tailings of composition and nozzle clay as they are drawn out by the auger bit. The drilling is done with a variable speed drill at very low speed to avoid any heat buildup. This fountain will need a healthy fire to get it going. A fuse is made by using a 4 foot length of quick match. The paper tube is removed from an 8 inch length on one end and 18 inches on the other end. Two lengths of bare black match, about 6 inches each, are cut from the long exposed end. These are bundled in parallel with the exposed length of black match that is still attached and tied with string. The three stick bundle is then painted with nitrocellulose lacquer and dusted liberally with 3FA black powder. The



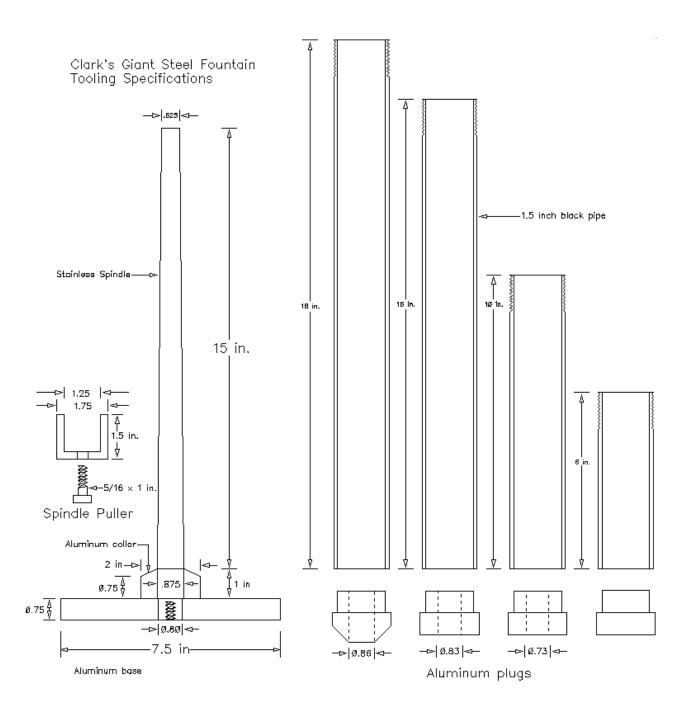
bundle end of the fuse assembly is then placed as far down the core as it will go. I like to add a bit of decorative flair by using colorful wrapping paper as a nosing to hold the fuse firmly in place. It is important to provide a secure base for this fountain. This one is built like a Christmas tree stand with two crossed pieces of wood. A short length of PVC is used to firmly clamp the base of the fountain to the stand. The stand has holes in the ends of the cross pieces where tent pegs can be driven through them into the ground to form a very secure anchor for the whole piece.



Here is the result of all this effort, prior to lighting the fuse. If you don't want to dress up your creation with party paper, plain craft paper will do the nosing just fine. The finished product is fairly impressive either way by virtue of its size and hefty weight.



Here is the result of all this effort, after lighting the fuse. The picture was taken from a distance of 40 feet with no zoom. It manages to fill the field of view with a 60 to 80 foot shower of beautiful golden, branching sparks. It makes a loud, throaty hissing noise like a rocket and is guaranteed to widen the eyes of even the most macho of your friends.



Six Pound End Burning Rocket Motors

This project page has been a long time coming, but had to happen sooner or later. It's the fulfillment of many of the childhood dreams that formulated in my imagination as I grew up flying the much beloved Estes model rockets. As many of you who were also bitten by the rocket bug in your youth know, the trend is always toward bigger and more powerful rockets. The black powder motor size topped out at D motors in those days and even today goes no further than E motors. I dreamed of monster motors back then and have only just realized the dream recently with these motors. I have not characterized them extensively, but my rough calculations indicate that these motors have a total impulse of about 200 nt-sec. and could be designated as H40 class motors. Although I have designed these motors to be used primarilly for display pyrotechnic purposes, they could easily be adapted for flying traditional model rockets with little effort. It should be noted that this project is quite advanced and is probably out of reach of most casual pyro hobbyists because of the tools and materials required. For this reason, I will not describe the project with all the detail needed to successfully attempt to do it yourself. Think of this page as an interesting general article about a "born again" rocketeer's experience with a truly impressive black powder rocket motor.



The true secret to this project's success lies with the paper tube that is used for the motor casing. These were custom ordered from New England Paper Tube through a fairly large cooperative effort of a aroup of fellow hobbyists. They are made from virgin craft paper, parallel rolled very tightly to make a very dense and strong casing. Every other commercially available tube I tried before these failed to stand up to the pressures needed to make the motors fly. The failure mode of these previous tubes was usually pin-hole ruptures in the motor walls that caused side venting of the exhaust gasses during motor burn. The failures were never catastrophic enough to cause motor explosions, but, nonetheless, caused poor flight performance. These tubes are 36 inches long, have an inside diameter of 1.5 inches and an outside diameter of just a hair over 2 inches. I usually cut them to 8 7/8







inches long so I can get 4 motor casings from one tube. Longer ones might be used for larger payloads or longer burns, and shorter ones, like the one on the right, would be about right for a stinger missile.

This picture is a close-up of the most important part of the tooling needed for the project. It is the spindle, which is used to form the rocket nozzle throat and cone. It is machined from a piece of 1/2 inch stainless steel and has a pressed aluminum collar. This spindle assembly is then secured to a base plate made of 3/4 inch aluminum. A drawing showing the dimensions of all the tooling can be found below.

The rammers and spindle are pictured here. The rammers are simple cylinders made from 1 1/2 inch aluminum stock. These would also make good murder weapons if you should decide to pursue the profession of hoodlum for hire.

A reinforcement sleeve is made from a piece of split 2 inch PVC pipe. At the pressures used to press the rocket fuel into the motor casing, this sleeve is essential to prevent casing deformation. Eight pipe clamps are used to compress the sleeve tightly against the casing.





Here we have an action shot of my new jumbo press being used to form the clay nozzle. Although this picture is about making a rocket motor, I can't resist the opportunity to brag a little bit about this beast of a machine. It uses a compressed air driven 20 ton hydraulic bottle jack. At the press of a button, I can apply up to 40,000 pounds of force. No more endless manual pumping of the jack handle, as on my original home-made rocket press. On the under side of the top press plate, I have mounted a custom machined hydraulic load cell to measure the exact applied force. The load cell bore has an area of precisely 2 square inches, making the gauge indicate exactly half of the actual applied force. The 10,000 PSI gauge gives me a measurement range of 0 to 20,000 pounds of force. I'll never need to apply that much force to make most rockets and fireworks, but knowing that I can gives me some kind of a warped sense of satisfaction.

After pressing, the clay nozzle looks every bit as good as any Estes rocket motor I've ever seen. For this one, I use a mixture of 60 grams of clumping kitty litter and 30 grams of wax treated kyanite and bentonite clay. It it pressed with 12,000 pounds of force and comes out hard and shiney. After the nozzle is pressed, 250 grams of milled black powder, mixed with 10-100 mesh titanium for a spark trail, is pressed into the motor casing at 8,000 pounds of force. I



use the hottest black powder I can make, using black willow charcoal. The finishing touch is the payload. This can be stars, flying fish or flash powder for a nice salute finish.

To close the end of the rocket after the payload has been added, a fair amount of tooling is needed to form a professional looking end cap. I use three layers of moistened cereal box cardboard glued together with wood glue. The layered cardboard disk is pressed into the end cap former using the ram and the press.

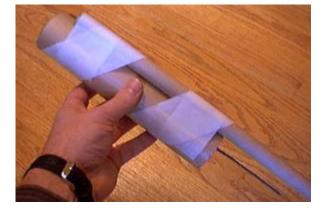


After the rammer has been pressed into the former, I use a utility knife to trim off the ragged edges. Because the cardboard has been moistened, it cuts fairly easily by rocking the knife edge against the rammer. The result, after drying for a few hours, is a very neat looking and strong end cap.



Because of the amount of compression in the cardboard, it is very difficult to extract the rammer from the former. I use a short piece of 2 inch PVC and a dowel pin, as shown here, to gently tap the rammer and finished end cap out of the former.

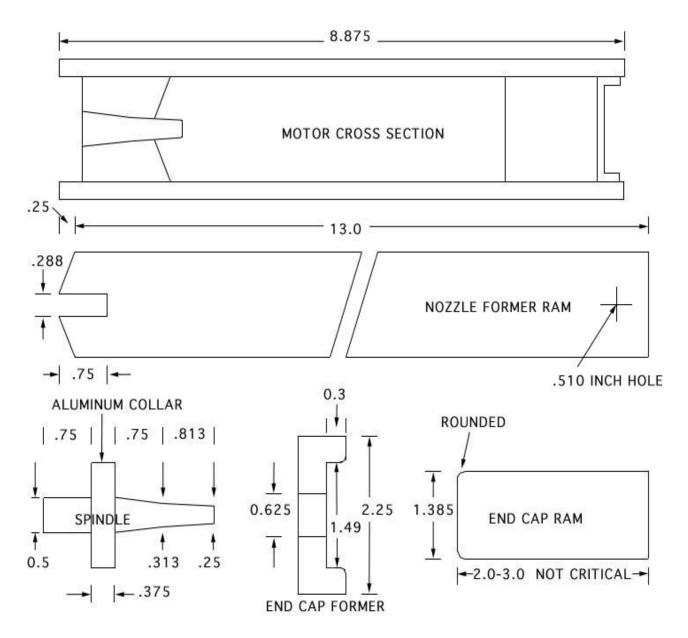




Here is the top end of the finished rocket motor, after the end cap has been glued into place. Now, all that remains is to add a stick and a fuse to finish the rocket. I use a six foot length of whatever I can find for the guide stick. A dowel, a piece of finish molding or even 1/2 inch ID roman candle tubing is simply taped to the side of the rocket casing using wide masking or packing tape. To accomplish motor ignition, a piece of visco fuse or my home-made thermalite fuse is placed into the nozzle throat and held there with a wad of tissue. A good long one is recommended to give the operator time to get at least 100 feet away. The effect of these rockets is hard to appreciate if you are too close.

The finished product doesn't look very impressive, but in action, it will blow your socks off. I wish I could capture the effect on film, but a picture just doesn't do it justice. The best I can do is describe it in words that are woefully inadequate. Upon ignition, the rocket jumps out of its launch tube with a burst of speed, due to a high initial spike of liftoff thrust. The noise is louder than a cluster of D engines and the tail of bright, golden fire is about 25 feet long. The 5 second burn puts these rockets up about 500 or 600 feet before the payload is activated. I enjoy a good salute finish the most because the altitude is so high that visual effects are fairly diminished in size. Well, there you have it.

There is a fair amount of detail that has been omitted in this description, but, hopefully, it has been enough to inspire some of you to discover the same fun and fulfillment that I have found in developing these big brothers to the cherished Estes rocket motors.



Tools and Tips for the Amateur Pyrotechnician

Easy Pyrotechnic Screen Boxes

Conventional wood framed screen boxes are usually about 1 ft. square and 3 or 4 inches deep. I find this much screen area to be more than is necessary. Cleaning them is difficult because of all the corners. Stacking them for multiple grain separations is awkward unless extra rails are added around the tops of the frames. Then you have more corners to clean. All these problems can be solved by using plastic storage containers as frames.



This is a typical shoe box size plastic storage container. They have very smooth, waterproof surfaces and rounded corners for easy cleaning. They should have stop tabs on the exterior which allow you to stack one inside another with about an inch of clearance between the bottom surfaces. They seal fairly well when stacked to control dust nicely.





First, get a sharp utility knife and cut out the bottom of the container, leaving about 1/4 to 1/2 inch of a lip around the edges. Usually the container will have a raised ledge molded into the bottom which makes a good guide for cutting.

Now cut your screens to size so that the screen is larger than the hole in the bottom of the container. You should be able to get 2 screens from a square foot of screen cloth. Two for the price of one!! Now, you will need some good tape (duct or strong masking tape) and some good quality epoxy glue.



Before applying the epoxy, you should rough up the gluing surface of the plastic with some coarse sand paper.





Then mix up the epoxy, apply along one edge, put the screen in place and apply the tape over the screen where the epoxy is. The tape should hold the screen tightly against the container frame while the epoxy sets. Now repeat the procedure for the remaining three sides. If you have a well behaved screen that lies nice and flat. you might be able to get away without using epoxy at all and only use the tape. This is much less trouble, but also much less durable as you can imagine.

Voila!! The finished result is a compact, stackable, light weight set of screens with a convenient catch box which is merely another unmodified container. I'm so pleased with them that I seldom ever use my original, wooden box screens any more.

A Better Pyro Funnel

Let's face it...pyrotechnics is a messy hobby. We work with a lot of compositions that contain very fine charcoal and metal powders that, when spilled, can make a nice mess of our clothes and workshop. Here's an idea that might help minimize one of the causes of spillage. Regular funnels usually have a long neck that clogs up easily with fine powders and clumpy compositions. Cardstock folded into a V-trough works a little better. This new funnel idea is a slight improvement on both concepts. It is also cheap and easy to do.



All you need is an empty soda can. You can probably get dozens from your cola-addicted Uncle Ned. Choose ones in pristine condition with no dents or wrinkles. Use a sturdy pair of scissors (not your wife's good sewing shears) and poke a hole into the side of the can near one end. Simply cut around the cylinder to remove both the bottom and the top of the can.



Now cut down the length of the can. When finished you will have a curly rectangle of aluminum about 4 inches wide by 8 inches long. From this rectangle you can cut two trapezoidal shapes with a long side of about 4 inches and a short side of about 2.5 to 3 inches. You can tailor the short side to the size of tube you will be filling with the funnel.



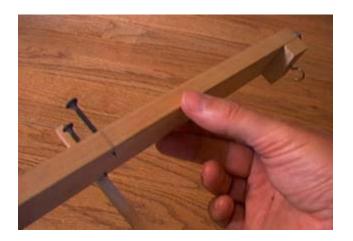
I usually rough cut the shapes with the scissors and then straighten all the edges with a desk top paper cutter. Finally, you will want to use the scissors to round off the sharp corners.



To use the funnel I either place some composition in the funnel while laying horizontally on the work bench and then pinch the short end to curl it as the funnel is applied to the target tube or I will hold the funnel in place and add the composition charge directly from the scoop. These funnels work so well because the aluminum has a smooth plastic coating which allows powders to slide easily and because their flexibility allows you to warp them to encourage the powders to slide. These funnels are easy to keep clean and, with care, will last a long time. When they get a little beat up, I just chuck them and make more.

A Home-made Balance Scale

If you want to get into amateur pyrotechnics, a scale is essential. A commercial triple-beam balance scale can cost \$85 to \$100. Electronic scales will cost you at least as much. If this kind of expense is a big obstacle to your pyro ambitions, then you might be interested in this low cost plan to build a balance scale.



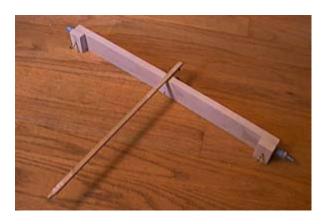
The heart of a balance scale is the balance beam. This plan uses a piece of hobby poplar, 1/2" X 1 1/2" X 16". You make a low resistance fulcrum with two sheet rock screws which protrude slightly from the beam to form the bearing points.

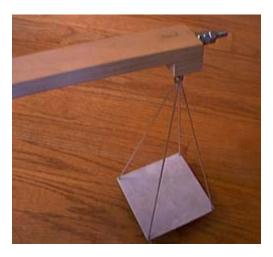


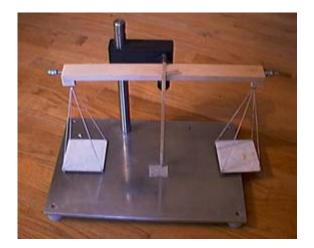
Some careful precision is needed to ensure that the screws are placed on a line which is perpendicular to the line of the beam. I used a Tsquare to draw the line and a drill press to drill guide holes for the screws.



The ends of the beam are constructed as shown to lower the swivel point of the weight pans. This is done by simply gluing another block of poplar to the bottom of the beam at each end. Next, the hooks are added from which the weight pans are hung. Finally, pieces of threaded rod are screwed into the ends of the beam and 2 or 3 nuts are screwed onto the rods. These are used as adjustment weights to cancel any asymmetries in the balance beam.







A pointer stick may be added to make it easier to detect when balance has been achieved while measuring chemicals. I used a left over piece of a model rocket kit and sharpened one end for the pointer. This is simply glued on with help of a square for alignment.

Weight pans can be suspended from the beam ends in many different ways. My first method used 2 loops of nylon kite string threaded through a square piece of fiber board bathroom paneling. A later improved method used coat hanger wire to support the weight pans.

The final part of the project involves constructing some kind of a stand for the fulcrum bearing surface. This can be accomplished with a simple vertical piece of wood which has a small metal plate mounted on top. A shallow groove is scored in the plate and the sheet rock screw points of the balance beam are placed into the groove. I used a surplus

microscope stand for my scale. I then made weights from pieces of plumber's solder which were weighed on a high precision electronic scale and trimmed to the desired weights. The final result is a scale which is highly accurate and incredibly cheap to make.

A Simple Hydraulic Press

This was one of my most enjoyable projects! It was done without great expense or special tooling. There are many ways to build a press with this approach. Maybe this particular plan will give you some ideas for building your own.



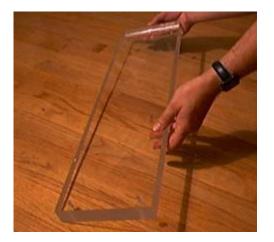
These first pictures show some of the major component parts of the press. This is one of two pieces of 4 inch wide channel. They are 16 inches long and are used at the top and bottom of the press. They are useful for mounting eye bolts and the blast shield as well as providing a



base for the large pressure bearing nuts. I chose to drill the two holes where the 3/4 inch threaded rod goes through. The task of drilling holes in a piece of channel is not nearly as daunting as drilling through 3/4 inch flat bar as shown below. This picture shows one of three pieces of 4 inch wide flat bar. They are 3/4 inches thick and 14.5 inches long. A notch has been cut in each end to accommodate a 3/4 inch threaded rod. As you can see, the cutting is very rough because it was done with a simple cutting torch by the metal dealer. These three pieces cost me \$15 and the torch cutting cost another \$5. You very well might do better if you try to find this material from a scrap

space in the





dealer.

This is the six ton hydraulic piston jack. I purchased it from an auto parts store for about \$20. The force of this jack is sufficient to bend the pieces of channel. This is why I needed to use the pieces of flat bar to reinforce the channel pieces at the top and bottom. This is a piece of 1.25 inch thick plexiglass that I used for the blast shield. I was very fortunate to receive this free from Donald Haarman who apparently salvaged it from a dumpster. Thanks again, Donald!! Part of the fun of these projects is the "scrounge" phase. Whatever is used for the blast shield, it's very important to include it. I certainly feel a whole lot safer with 1.25



inches of plexiglass between the press and my face.

This close-up view of the top shows the channel placed on top of the flat bar. The threaded rods hold them both in place with a nut and washer on each side. The blast shield is bolted to the channel through a wood offset block. This gives me a little more working room around the middle pressing deck.



the press is assembled identically to the top. The retraction springs are attached to eye bolts which are mounted through the base channel.

The base of



This picture shows the attachment of the blast shield to the base channel. You can also see the bolt which secures the base of the hydraulic jack to the base of the press frame.



This view from the opposite side of the blast shield illustrates the attachment and placement of the retraction springs. The springs add stability to the middle pressing deck and conveniently retract it when the release valve of the jack is opened. These springs are fairly expensive at \$2.85 apiece, but are well worth the contributions they make to the design.



Finally, the finished product is shown. This press design was partially inspired by a similar plan sold by Firefox Enterprises. The major difference is that the Firefox design places the hydraulic jack on top of the pressing deck and the object to be pressed is placed on the base of the pressing frame. This way, the pressing surface comes down from above, whereas the design shown here causes the pressing surface to push up. If you are interested in the Firefox design, it only costs \$4.00.

Comments and suggestions from reader feedback:





This idea comes to you from Rich Weaver. I liked it so well, I made the modifications to my own press. The concept is to add protective sleeves around the threaded rods to prevent the press deck from scraping against them as the deck is raised and lowered. I made the sleeves from 3 inch lengths of 3/4 inch PVC conduit pipe. I glued a coupler on one end and then cut the coupler right down the middle. The PVC tubes had to be notched a little to allow them to fit into the slots of the press deck.

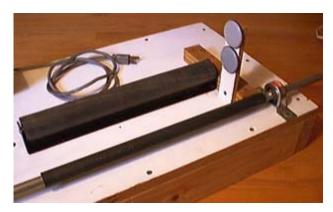
The sleeves are installed by using the coupler rings that were cut off in the step above. The rings are glued and slid over tubes to lock them into place in the slots of the press deck as shown. The tubes now act as guides that give the deck a little more stability and keep it from binding or scraping against the threaded rods.

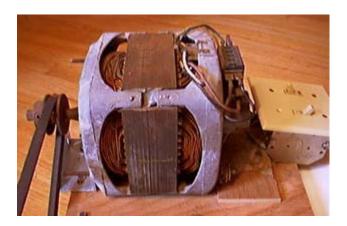
A Ball Mill

I approached this project the patient way and started by first ordering the milling bible entitled "Ball Milling Theory and Practice for the Amateur Pyrotechnician" by Lloyd Sponenburgh. I have not faithfully followed his plan, nor do I expect you will follow mine. However, for those of you who are dying to build your mill without buying the book, this page illustrates the general approach.



I have pictured the entire mill here for visual reference as you look at the remaining illustrations.





First, you have to decide what kind of frame to mount your mill on. I simply made a rectangle with 2 X 4's and screwed two layers of 1/2 inch plywood on top. Lloyd's plan gives all the patterns to build a nice milling cabinet with its own stand..Whatever you use, it must be very sturdy!! These mills must endure heavy vibration and weight loads.

The electric motor should be a 1/3 to 1/2 horsepower, capacitorstart, 1725 rpm, 115v motor. You can get one from Grainger using part # 6K758. In my case, I am using a motor salvaged from a washing machine for which I paid \$10. Since it has coils for 2 speeds, I used 2 switches. One switches between hi and low speed and the other is the on/off switch. It turned out that I only use the fast speed, so the speed switch is superfluous. The shaft sheave on the motor should be 2 inch o.d. by 1/2 inch (Grainger #3X895).



The drive shaft for the mill is 5/8 inch round steel bar stock. These can be purchased at any hardware store. Be sure it is perfectly straight. The sheave on the drive shaft is a 6 inch o.d. by 5/8 inch (Grainger #3X919). This cost me \$3.72. You will also need two selfcentering ball-bearing pillow-block bearings to mount the drive shaft (Grainger #2X898). I had to sand the drive shaft a little bit to allow the bearings to slide onto the shaft.



Before placing the bearings on the shaft, you need to place a piece of automotive heater hose on it as shown here. This hose is 5/8 inch i.d. by 7/8 inch o.d. It can be found at most hardware or auto parts stores. A little lubrication of some kind on the shaft will greatly aid the sliding on of the hose.

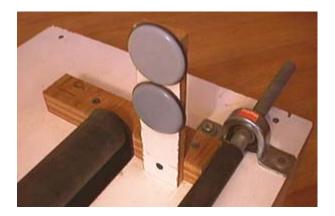


The other side of the mill jar cradle uses a ball bearing equipment roller. I bought this one at Woodworker's Warehouse for about \$10. This picture shows the roller removed from its bracket. The roller has been covered with two layers of bicycle tire inner tube. The inner tube layers have been folded back in the picture for illustrative purposes only. You may be wondering how to get the inner tube layers over the roller. Again, Lloyd describes a

technique which works very nicely.

If you mount the drive shaft and equipment roller perfectly parallel,

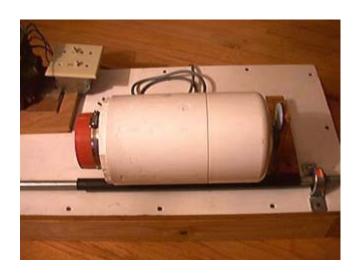
Start with a 26 inch by 2 inch bicycle tire inner tube. Cut the deflated tube about 3 inches from the valve stem and tightly tie a cord around each end so the tube can be inflated to look like a long three inch diameter sausage. The trick is to push the roller end into the end of the inflated inner tube. When the roller is completely enclosed by the inner tube with a few inches of overlap, you can cut the sausage off near the valve stem to allow it to deflate. You now have two layers of rubber over the roller which are connected at one end. After allowing the rubber to relax a little bit, you can now trim the ends with scissors to within 1/4 inch of the ends of the roller. Now re-install the roller in its bracket and check for unimpeded rotation.



your mill jar may not creep as it rolls in the cradle. To be safe, I installed this bumper to prevent the mill jar from exiting its cradle. I used two Teflon furniture slides on the bumper to allow the mill jar to slide against the bumper with little friction. The drive shaft and equipment roller are mounted with 3 inches of space between them to accommodate both a 4 inch and 5 inch mill jar. A 6 inch mill jar requires a space of 4.5 inches.



This is a mill jar which has been constructed from 5 inch PVC pipe and fittings. The milling media is antimony hardened, 3/4 inch lead balls. The construction of the jars is relatively simple, but is a subject for another project page.



Finally, this shot shows the placement of the 5 inch mill jar in the cradle. With this setup, I can mill about 3 1/4 cups of high quality black powder in about 3 hours. The efficiency of this mill is dependent upon many factors which are explained in Lloyd's book. There is a wealth of information about milling theory contained in the book and I would highly recommend the serious pyrotechnician to purchase it. You can find it in the books and video section of Skylighter's web catalog.

A Charcoal Cooker

There are as many ways to produce charcoal as there are pyro enthusiasts. There are certainly many approaches that are simpler than my method. I will try to point out the advantages of this particular charcoal cooker and leave it to your judgement to determine whether it has merit. As always, I invite critical commentary, but praise and homage is preferred.



This is a typical 22.5 quart or 6 jar canner pot. It is used to can fruits and various garden grown produce. The pot is constructed of fairly light weight sheet metal which has a tough porcelain finish. It comes with a wire basket which holds the canning jars securely inside during the canning

process. You can purchase one of these at Wal-mart type stores for about \$14.00. This is used as the "oven" part of the charcoal maker. There are many alternatives to using this particular kind of pot. Various metal drums or metal buckets will work just as well.



A lid for your "oven" must be fashioned with a hole in it where the hot gases can exit. The idea is to create a draft of hot gases from the bottom of the oven to the top. If you use this kind of pot, it's a good idea to cut the hole with minimal damage to the surrounding porcelain.



Next. the holes in the bottom of the pot are made. I placed a length of 3 inch paper mortar tube with its face against the inside bottom of the pot, beneath the site of each hole. This gives firm support to the bottom surface which avoids cracking the porcelain while the holes are formed. A sharp blow with a hammer on a center punch creates a hole

about 5/16 inch in diameter. I created 30 holes in an evenly distributed pattern on the entire bottom of the pot.

Now, the theory is that the oven temperature could be regulated by the number of holes in the bottom. More holes allow more draft and consequently a hotter fire. I tried to create the holes in groups that would accommodate the addition of rotating hole covers. This should achieve the desired temperature regulation, but I have yet to experiment with this concept. Currently, the 30 holes result in an oven temperature of about 575 degrees F. Another enhancement would be the addition of standoff feet on the bottom of the cooker. I just set the pot on 3 rocks during operation.



Now we turn our attention to the retort container. This pot is a miniature version of the oven pot. I bought it at a garage sale for \$1.00. Wood stove cement and fiberglass gasket material were used to seal the lid which is held in place by 4 mini C-clamps. A single 5/16 inch hole was punched in the lid to vent the smoke from the retort. I like this retort can because it will last for dozens of uses before it will need to be replaced. The handle is handy for lifting it in an out of the oven with a wire hook.





Many simpler alternatives can be considered for the retort container. These Christmas cookie cans work great. Add a couple of screws to hold on the lid, put a hole in the top or bottom and you're all set. (Editorial comment: You know you're a pyro when you buy stuff you don't need just to get the container. I don't care for these cookies, but I will gag them down just to justify buying the can.) My objection with this approach is that this kind of container will only last for about 5 or 6 roastings before the thin metal walls loose their integrity. Then I have to eat more cookies.

If you really want to become a gourmet charcoal cooker. you might want to consider buying one of these flu thermometers. This one cost \$11.00 and was purchased at a hardware store that carries wood stove products. It is magnetic and will stay anywhere you put it on the retort if the retort is made of iron. Perhaps you are asking....Why do I care what the temperature is in my oven?

Let's slip into the theoretical domain again for a moment. Charcoal made at lower

temperatures contains a higher percentage of volatiles in it. This leads to black powder that ignites easier, which would be desirable for black powder based primes. Charcoal made at higher temperatures contains less volatiles, ignites at higher temperatures and may be more desirable for creating lift and break powders. I don't know if there is a strong consensus among the pyro community for these theories. At any rate, the addition of the above temperature gage to your retort gives the appearance to the uninitiated that charcoal making is nearly as complicated as rocket science.





OK, we've finished making our primo charcoal cooker. Let's talk about how to use this hi tech apparatus. Perhaps the most labor intensive part of making charcoal is the preparation of the wood. When using willow, you must remove the bark and split the sticks into smaller sticks no thicker than 1/2 inch. I load the retort as full as possible with the sticks oriented vertically.

Now we need a fire in the oven. I use two layers of regular barbecue briquettes to fuel the fire. I place the briquettes in the bottom of the pot with the wire basket in place. The handles of the wire basket are removed so they don't interfere with the placement of the retort. This keeps the retort from settling and choking off the intake holes at the bottom of the pot. My kids think it's pretty funny that I use charcoal to make more charcoal. I'm afraid they tell their

friends, "He's a nice guy, but sometimes he ain't too bright!" This picture shows the cooker in operation. The flu temperature gauge is placed so it is visible from the hole in the lid. A nice column of smoke is rising from the retort vent and the smell of smoky campfire fills the air (and sometimes my house when the wind is right.)

A close examination of the smoke column reveals an interesting fact about the operation of this cooker. The smoke is not visible until the gas jet rises several inches above the retort vent. This implies that the escaping volatiles don't condense into visible smoke until they cool in the rising column. This is the main advantage of this kind of charcoal cooker. Allow me to explain...

In my days as an apprentice charcoal maker, I would simply place the retort can over an open fire. I found that it was difficult to achieve a steady, well controlled heat source. I had to constantly add fuel to the fire and check it often. Even with great attention, the heat was not distributed evenly. The result was that there were often cool spots in the retort where the charcoal was brown instead of black, indicating that the wood conversion to charcoal was not complete. Even worse, cooler areas of the retort lid would allow condensation of the reaction gases on the inside of the lid. The accumulation of these tars left a mess that was impossible to remove. All of these problems are eliminated by the new cooker. Now, the retort stays fairly clean, I don't have to constantly tend the fire and the temperature is even and controllable.



Finally, the result of all this effort is beautiful, almost shiny black charcoal. Getting it into usable form is another story. I use a meat grinder for the first stage of reducing it to useful grain sizes. Tom Perigrin suggested in the April 98 AFN that you use gallon size zip lock bags, remove excess air and whack and roll it with a PVC pipe. The resulting

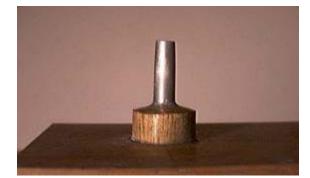
charcoal powder is then graded with various screens. For airfloat, of course, you will need a ball mill. Whatever your method, you will get pretty grubby and will probably blow black stuff in your kleenex for a week.

Tips for Fountain Tooling

Some of my first successful pyro projects were fountains. I still enjoy the simplicity and quick reward of making a finely crafted fountain. I prefer choked fountains because, in general, the higher internal pressure produces a greater height of fountain spray. In other words, a bigger effect is achieved for your efforts. Consequently, my fountain tooling is very similar to rocket tooling. A choked fountain is, after all, an inverted rocket with fuel designed for special effects. I offer here a few tips for making your choked fountain tooling. The illustrations depict tooling for a 3/4 inch I.D. fountain.



There are only two basic tools in the tooling set for fountains. One is the nozzle former, or spindle, and the other is the rammer, or "drift" if you want to use a nice buzz-word. The first step in making this tooling is to drill a hole into the end of a dowel to serve as the rammer. The hole is the same diameter as the spindle which, in this case, is 1/4 inch. The dowel is the same



diameter as the I. D. of the intended fountain tube. Getting this hole perfectly centered and aligned is a challenge, even with a drill press. The hole is made about 2 inches deep because a 1 inch piece is then cut off to serve as the spindle collar.

To construct the spindle, I start with a 1 3/4 inch length of metal rod. Ideally, this rod should be made from a soft, nonsparking metal such as brass or aluminum. The diameter of this rod determines the throat diameter of the resulting fountain nozzle. A general rule of thumb is that the nozzle throat diameter should be about 1/2 of the fountain's inside diameter. This tooling uses a throat diameter which is 1/3 of the fountain diameter because I tend to push my fountains to their limits. Consequently, I always use very sturdy tubes for the fountain body. The length of this spindle is designed to extend only a short distance beyond the clay nozzle material and into the fountain composition. The desire is to create a small cavity where enough surface area of the fountain composition is exposed to enhance ignition. If the spindle

is too long, the fountain becomes more like the typical black powder rocket which has a long core for high thrust.

Now, I am about to reveal tip number one.... get out your pencils and pay close attention. The part of the spindle rod which extends beyond the spindle collar should have a few degrees of taper in it. If you don't have a \$5000 milling machine, you can accomplish this easily the poor man's way. Put the spindle rod in an electric drill and use a sanding block to wear away a little bit of the spindle surface. Start with about 320 grit sandpaper and finish with 600 grit to add a nice polish. This little bit of effort will greatly ease the extraction of the spindle tooling from the fountain when you are done ramming the contents into it.

To complete the spindle tool, a 3/4 inch hole is drilled into a piece of hardwood to a depth of 1/2 inch. The spindle collar is glued into this hole with epoxy and the spindle rod is inserted into the collar. Here comes tip number two..... apply epoxy in the spindle collar hole and on the top of the spindle collar. The epoxy should adhere to the spindle rod and form a nice, rounded fillet between the rod and collar. This effect is visible in the picture of the spindle above. The purpose of this enhancement is to create a rounded edge in the fountain nozzle.

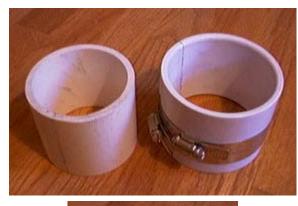


Before I started using the epoxy fillet, the sharp edge of the nozzle throat would usually crumble in a few places as the spindle tooling was extracted. Now, as shown in this picture, the nozzle throat comes out perfect every time. Your fountain nozzles will be the envy of all your pyro buddies.

A Powder Die

This powder die design was invented by Lloyd Sponenburgh. In fact, this die was even made by Lloyd because I bought it from him when he was still in the business of selling BP making tools. Unfortunately, Lloyd no longer sells this useful item, but you can fairly easily make your own. He has, however, described how he makes them in the pyro news group. I assume he won't mind if I do the same on this web page.





This is the base of the powder die. It consists of a five inch length of 3 inch I.D. PVC and a base cylinder of cast resin. The cylinder looks a little blotchy because of black powder stain and is guite heavy because of its length. The only utility of this exaggerated length is the avoidance of excessive blocking if you use a press with high clearance. A much shorter, lighter base would still work just fine. Notice that the PVC sleeve is held fixed, relative to the base cylinder, by a set screw. The function of this sleeve is to position the cylinder a defined distance into the compression sleeves pictured below.

The compression sleeves are made from a 3 inch length of 3 inch I.D. PVC and a "repair sleeve". The repair sleeve is similar to a coupler, except it has no stop ridge in the center. Both of these sleeves have been split by cutting with a very narrow kerf blade down the length of the sleeve. In use, one sleeve fits inside the other, with the splits opposite each other, and they are restrained from expansion by two common pipe clamps.



When placed on the base, the compression sleeves form the walls of the chamber where black powder meal is placed to be pressed.

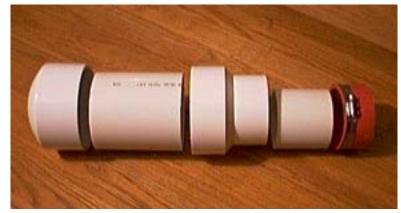
The top piston is another cylinder, similar to the base cylinder, which has been made from a casting of resin. Read the feedback at the bottom of the page from Lloyd to find out about how to make these castings.



The top piston is placed into the compression sleeves after the black powder meal and pressed until a known density has been achieved. On this top piston, a groove has been placed to indicate that when it is even with the top of the compression sleeves, 8 ounces of meal will be at the desired density of 1.7 grams per cubic centimeter. Likewise, 4 ounces of meal are pressed until the top of the piston is flush with the top of the sleeves. The press cake that results from this pressing process will be very hard and sounds like china when tapped. After corning, you will have a very durable, hard grained powder.

Ball Milling Jars

As with most home-made tooling, there are many ways to make milling jars. I have yet to see a design I like better than this one which uses PVC pipe and fittings. The jars are very sturdy and will last for many years. Their initial description was supplied by Lloyd Sponenburgh.



The quart size jar uses 4 inch PVC and fittings. It is the smallest and cheapest jar to construct. However, its milling capacity is so small that it is only useful for small batch, specialty milling. This is the parts list: a 4 inch end cap, a 5 inch length of 4 inch I.D. schedule 40 PVC pipe, a 4 inch to 3 inch reducer, a short stub length of 3 inch I.D. PVC and a rubber test cap with band clamp.





The above parts are all glued together with PVC glue to yield this result. As you can see, the jar with the flat end cap is nice because it will stand up by itself. If you use a rounded end cap, I recommend putting 3 rubber feet on the bottom of the end cap to stabilize it. The rounded end cap also results in a larger capacity jar. The actual total capacity of the flat bottomed jar is about 1 quart plus 1/2 cup. It will require a volume of 1 pint plus 1/4 cup of milling media and will yield a charge of 1 and 1/8 cups of milled powder. This illustrates the Sponenburgh rule of thumb for milling jar capacity which is: Fill your jar half full of milling media to mill a charge of 1/4 of the jar volume.

The 5 inch jar is about right for most of my milling jobs. The same parts as above are needed, but in the 5 inch sizes. There are a few quirks, however. The supplier in my area does not carry a simple 5 inch to 3 inch reducer. The reducer shown fits inside the 5 inch coupler. This requires the addition of the coupler to the above parts list. The other complication is







that there are lots of ridges and raised lettering on the outside of the coupler that have to be removed to achieve a smooth outer surface on the jar.

Shown here is the rounded end cap, a 6 inch length of 5 inch I.D. PVC and the coupler with the raised ridges removed. A radial arm saw was used to remove the ridges, but a belt sander would probably work better.

When these three parts are glued together, the 6 inch length of pipe becomes entirely enclosed by the coupler and endcap because the distance of insertion into each one is 3 inches.

The reducer is prepared by clipping off the corners which otherwise would protrude beyond the outer surface of the jar. A short length of 3 inch PVC is cut so that 3/4 inches will protrude for the attachment of the rubber test cap lid. Note that the lid in the next picture has been trimmed back to a width of 3/4 inches to make it much easier to attach and remove.



The final volume of this jar is 3 1/4 guarts and the charge capacity is 3 1/4 cups. Again, the addition of stick-on rubber feet to the bottom of the rounded end cap is recommended. A few final notes: Mill jars, like screens should be reserved for certain classes of milling. I have separate jars for milling black powder, oxidizers, (chlorates get their very own jars) benzoates and binders. Care should be taken with your milling media, as well, to avoid cross contamination. I use ceramic media to mill most single substances. Lead media is used to mill black powders, rocket fuels and charcoal. This same approach can be used to make milling jars of 1 gallon capacity by using 6 inch PVC pipe and fittings. The drawback is that a jar of this size will require 30 pounds of lead milling media. That represents a big pain in my back to lug around and in my wallet to purchase the media.

Comet Tooling

Comets are in a class by themselves. With a bright, fiery head and a long, full tail, they are one of my favorite display effects. Add to this the surprise of a crossette finish and you've got a real crowd pleaser every time. The tooling described on this page will enable you to make most varieties of comets for a 3 inch mortar. The tooling techniques should be scalable to any size comets you want to make.



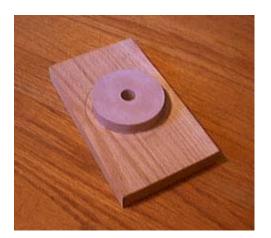


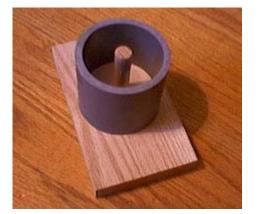


First, we need to gather materials to use for the base and sleeves in the tooling set. I used a piece of oak with dimensions of 3.5" X 6" X 5/8". The sleeves are cut from a piece of 2.5 inch schedule 40 PVC conduit pipe. One is a 1/2 inch slice and the other is 2.5 inches long. Each piece of conduit has been cut along its length by using a coping saw with a very narrow kerf.

A 1/2 inch hole is drilled at the center of a 2.5 inch circle on the base block. A short length of dowel is placed in the hole so that it protrudes to a height of 1/2 inch. The other end of the dowel is flush with the bottom of the base block.

The inside of the 1/2 inch slice of conduit must be coated with vaseline or bearing grease to act as a mold release. It is then tacked in place by using hot glue. The exposed surface of the small dowel should also be coated with mold release. This assembly can now be used to mold a raised cylinder onto the base block.





I chose to use auto body putty because it's cheap and readily available. A \$5.00 can of Bondo will be sufficient for this entire set of tools. Another option would be epoxy or some other resin system. Of course, if you have a wood lathe, you could make all the necessary shapes from wood and skip all the fuss of casting them. When you are done, the base should look like this picture. You should retain the small length of dowel as part of this tool set. It will be used to fill the hole in the base when you are pressing a comet which has no central core.

The 2.5 inch length of PVC sleeve is now used in a similar manner to cast a rammer piston with a hole in it. It is placed over the base cylinder to hold it in place, so it shouldn't be necessary to tack it down with hot glue, as before. Again, the inside of the sleeve must be treated with mold release grease. The dowel is cut to be even with the height of the sleeve and is wrapped with a few layers of tape so the hole in the piston will be a little larger than the dowel. I also placed a circle of wax paper in the bottom to protect the base cylinder. The wax paper and the dowel are also treated with mold release. Unless you are extremely skillful at using Bondo, I suggest you cast the rammer piston in several steps instead of with one batch of putty. Bondo will gel within 4 minutes, which gives you very little time to mix it, get it into the mold and get out the air bubbles before it's too late. I used three small batches of

80 grams each. Again, if anyone could suggest a better resin system, I would love to hear about it.



With a little luck, your rammer piston should look like this.



These rammers have been formed using the same techniques described above. The solid one on the left is used to press comets that have no central core. The one on the right is used to create the interface between priming compositions and hard to ignite comet compositions, such as flitter and other high metal formulas. The shape of the rammer face produces ridges of comet composition that are covered with prime composition. These ridges are much easier to raise to ignition temperature than a flat surface would be. This rammer was made by cutting pieces of hardwood to form the ridges and gluing them on the face of the rammer with epoxy.







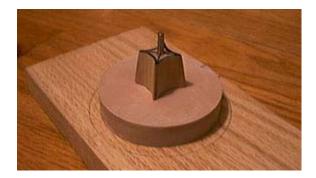


The last part of the tool set is the crossette insert. I started by marking the face of a 1 inch hardwood dowel as shown. The arcs are drawn with the aid of another piece of 1 inch diameter dowel. A hole is drilled in the center to accommodate the insertion of a tapered pin later. A length of 11/16 inch of the drilled dowel is cut from the end.

The opposite face of the dowel piece is now marked with the same pattern inside a 3/4 inch circle. This time, the arcs are drawn using a piece of 3/4 inch dowel. The pattern must be precisely aligned with the pattern on the opposite face.

Straight cuts are made which create a square on each face of the dowel, one being smaller than the other. This creates the desired taper in the insert.

The curved surfaces are carved out by any of several possible techniques. A Dremmel tool would work nicely. I used a straight edge bit in a router mounted in a router table. Even hand carving with a pocket knife would work if you have a little patience. To finish the crossette insert, the completed dowel piece is glued to a short length of a 1/2 inch dowel and the tapered pin is set in place with epoxy. The length of this pin will determine when the crossette will burst while in flight. I make the pin a little long and shorten it to



taste after experimenting with a few test comets. Finally, the shaped part of the insert should be sealed with a good finish of some kind. I used a thin coating of epoxy followed by light sanding.

In use, the insert is placed in the base, as shown, to form the burst charge cavity in the end of the comet body. The shape of the cavity is specifically designed to ensure that the crossette will burst into 4 equal pieces, creating a beautiful glittering cross in the sky.

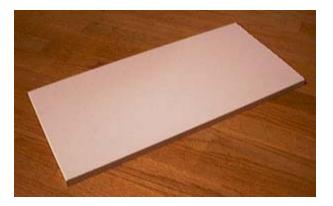


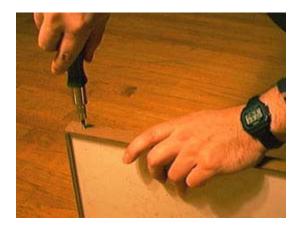
This is the complete set of comet tooling for 3 inch comets. There is a short dowel to fill the hole in the base cylinder when pressing solid comets. Another longer length of dowel is used to press comet "cookies" with a hole in them for cored comets. These cookies dry out much sooner than entire comets would. They are then stacked and glued together with nitrocellulose lacquer. Next there is the crossette insert followed by three specialized rammers. One for pressing cored cookies, one for pressing solid cookies and one for priming flitter comets. There are two PVC sleeve lengths. One is used to press the cookies, which are 1/2 to 5/8 inches thick. The longer sleeve is used to press crossette sections and complete comets when the cookie method is not used. Both sleeves use hose clamps to prevent expansion during pressing. Last in line is the

base, which has a 1/2 inch hole in the center of the raised cylinder. When you are ready to used these tools to create breath-taking comets, check the forthcoming projects pages to see them in actual use.

A Star Cutting Board

Cut stars are a mainstay for most of the amateur pyro folks, but they are tedious to make. If you are a stickler for nice, uniform stars, then you might like the design of this cutting board. It helps you cut perfect cubes without any eye-straining guess work.



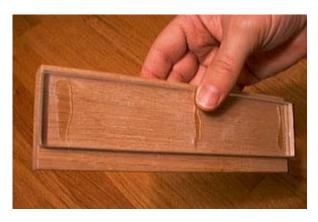


I started with a piece of 10 inch wide, plastic surfaced shelf board. You can buy them for a few bucks at Home Depot or HQ with a wood grain or white finish. This board has been cut to a length of about 16 inches.

Next, attach edge quides to two sides of the board with screws. The edge guides should protrude above the cutting surface of the board no more than the size of the smallest stars you plan to make with this board. I used a few strips of plastic surfaced paneling for bathrooms. Personal preference is used to decide which corner of the board you prefer to work in. The sides of this corner are the ones where the edge guides are attached.



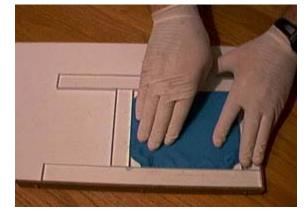


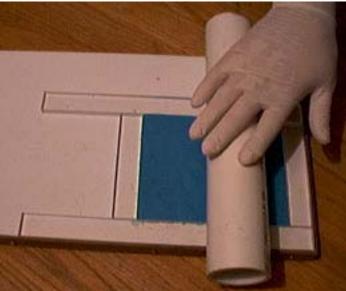


The star cutting board is complete. To use it, you will need to make a set of tooling for each size of star you want. To do this, three pieces of gauge strips are cut from wood or plexiglass. One of these strips is then cut into two short lengths of about 4.5 inches. The thickness of the gauge strips is the same as the size of the stars you want to make. The gauge strips shown are 3/8 inches thick and will yield (real rocket science here) 3/8 inch cut stars. If wood is chosen for the gauge strip material, it must be sealed with polyurethane and warping may still be a problem.

The strips are used to border the sheet of dough as you roll it out. The two strips which contact the edge guides are held stationary by the guides. The other two are held in place by hand. The short one is adjusted to the size of the dough batch.

Now, another piece of plexiglass is glued to a piece of wood to act as a cutting guide. It is placed with one edge recessed from the bottom, as shown. The recess should be greater than the star size by about 1/8 inch. The plexiglass is attached to the wood by several dabs of hot glue which hold the plexiglass away from

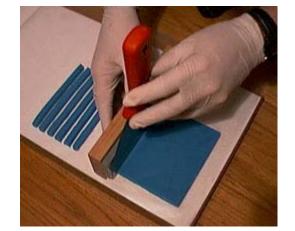




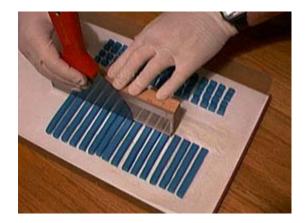
the wood by roughly the width of the blade of the cutting knife which will be used to cut the star dough. The reason for this will become apparent shortly (if I manage to make myself clear). Again, the wood should sealed by some means to facilitate cleaning after use.

To start making a batch of cut stars, I put down a piece of wax paper and then place the gauge strips on top of it. I then use my hands to roughly flatten the lump of star dough within the gauge rails.

I then use a piece of PVC as a rolling pin to flatten the dough to a very uniform thickness. If the dough is somewhat sticky, I might use a piece of waxed paper to cover the dough while rolling. The gauge rails are then removed, leaving a very well formed rectangular sheet from which to cut strips of star dough.



The cutting guide is now used with a wide putty blade to cut the strips. The guide is designed to assure the cuts are vertical and uniform in width. To use it, I bring the wooden surface into contact with the dough, as shown. This is done lightly so the dough is not encouraged to adhere to the guide. Holding the knife against the plexiglass surface of the guide, I lower the knife onto the dough and gently mark a line into the surface of the dough. Then I back away the guide until the knife edge is outside of the mark in the dough. Now, with downward pressure on the guide to hold it stationary, the knife is pushed down into the dough to cut off a strip. This cutting action will force the strip of dough away from the rest of the sheet by exactly the width of the cutting knife blade. There is room for this to happen without forcing the dough into the guide because the guide was initially backed away by this much distance. The whole intent of this procedure is to avoid causing the dough to stick to the guide or the knife. The severed strip is then slid or rolled away from the sheet with the cutting knife. Each strip is left beside the next with a small separation between each one.



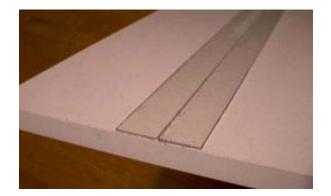
Finally, the cutting guide is again used to cut the strips into cubes. Unless a different, much longer knife is used, two cutting actions will need to be performed for each new row of cubes cut from the strips of dough. If the star dough becomes dry and crumbly before all the cutting is finished, I often mist the dough with a spray bottle of solvent to keep the dough moist. When the cutting is done, the wax paper is lifted or slid off the cutting board with the stars on it and placed on a rack to dry. If priming is necessary, I usually do this after the stars have dried. In case you're wondering what kind of bizarre star composition this is, an inert, dyed salt dough was used to illustrate this marvelous star cutting method. Had you guessing, didn't I??

Perfect Sticky Match

Sticky Match (see note below) is pretty cool stuff. It has become very popular as a replacement for quick match in set pieces where fire must be passed quickly to a lot of different pyrotechnical devices. I even use sticky match as leaders for my aerial shells and mines. The problem is that both sticky and quick match can't be purchased through the mail like visco and common pyro chemicals. Thus, the amateur pyrotechnician is often left with the prospect of making his own. The effort of making quick match is considerable, but sticky match is relatively easy. This is why I have designed this simple method to make sticky match.

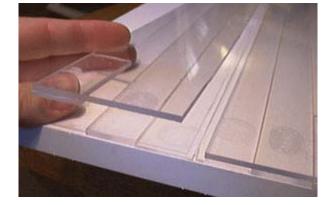
Note: The name "Sticky Match" is a Registered Trade Mark of Four-D Enterprises, Inc. Patent Number 5,662,719. All uncapitalized uses of this

name refer to the home-made equivalent described in this page.



This design uses 3 foot long strips of material to form masks that aid in accurately placing black powder grains on 2 inch packing tape. Acrylic was chosen as the material in this case, but many other alternatives are possible. The 3 foot length was chosen because most of my 3 inch shells, comets and mines use a leader fuse about this long. However, this contraption can be used to make sticky match of any desired length. The first step in building it is to cut two strips of 1/16 inch thick acrylic. They are 3 feet long and just a whisker less than 1 inch wide. A table saw or radial arm saw is recommended for making these cuts very straight and accurate. The cut edges are sanded gently to smooth and clean them from cutting burrs. They are then mounted down the center of a very straight foundation board as shown. The board, in this case, is a plastic surfaced, 10 inch by 3 foot shelf board, like the one used for the star cutting board. It costs about \$6.00 at most home improvement and hardware stores. The two strips of acrylic are mounted such that the space between them is about the width of a utility knife blade. The function of the space is to guide the knife blade as it is used to split a two inch wide strip of packing tape into two 1 inch strips of tape.

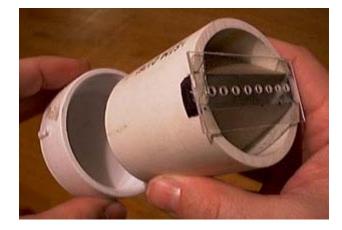




Two 1 inch wide strips of 1/8 inch thick acrylic are now cut to the same length of 3 feet. Next, two more strips are cut for the masks which have a width of 2 3/4 inches. (These are also from 1/8 inch acrylic stock.) Finally, 4 stop tabs are cut to a size of 1 inch by 2 inches. You are now done with all the acrylic cutting required for this project. You may sweep up the floor and brush the acrylic shavings out or your hair. The two long 1 inch wide strips are mounted beside the first strips on the mounting board. You should now have 4 strips mounted on the board which form a 2 inch wide recessed track down the middle of it.

The masks are now made by gluing the stop tabs to the 2 3/4 inch mask strips. The picture shows the placement of the tabs at one end of the mask strips. The other stop tabs are glued at the opposite ends of the masks. Instead of two separate tabs, a single 3 foot long strip could have been used to attach along the edges of the mask strips. The placement of these tabs (or complete strips, if used) determines the distance that the masks will overhang into the recess mentioned above. If the tabs are glued flush with one edge of masks, as shown, the overhang will be 3/4 inch. This results in a 1/2 inch wide portion of the 2 inch packing tape being exposed for the placement of powder grains. Finding the right glue for these steps might be a challenge. Hot glue and epoxy will not adhere to the acrylic very well. I finally settled on something called "Zap a Dap

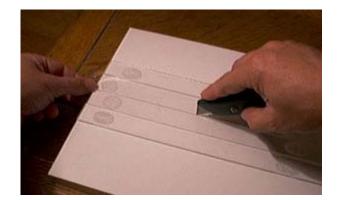




a Goo II". It is a sealant and adhesive that is a little less viscous than silicone sealant.

Next, some method must be contrived to mount a roll of 2 inch packing tape at the end of the mounting board. The roll is mounted below the working surface of the board to achieve a little tension in the tape as it rises and folds over the end of the board into the recessed track. This helps assure that the tape will lay very flat inside the track. The tape mounting system shown is built from 2 inch PVC parts. The pipes are attached to the board with bolts which hold them very securely in place. The elbow joints are not glued together, but rely only on the friction fit of the joint, which is considerably strong. This way, the mount can be disassembled to add a new roll of tape. In actual use, the end of the mounting board, where the tape roll is mounted, is suspended over the side of the table or work bench surface so that the board can lay flat.

The tooling is completed by making a nifty little shaker to evenly distribute the grains of black powder on the packing tape. This one was made from a short piece of 2 inch PVC pipe. An end cap serves as a lid. A piece of acrylic with 1/8 inch holes was glued on the other end. Small, cardboard baffles were installed inside the pipe section to constrain the black powder grains to fall through the holes, but this is probably not necessary. If you don't want to be this fancy, the same function as the shaker can likely be accomplished by using a

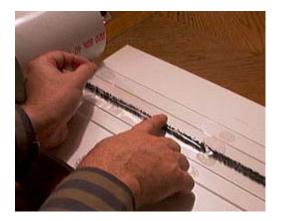


small scoop or spoon to sprinkle BP grains on the tape.

Now let's take a look at how this tooling is used to make "perfect sticky match." First, a 3 foot length of 2 inch packing tape is drawn from the roll. Unfortunately, the clear packing tape used in this demonstration doesn't show up in the photos verv well, but I prefer the clear tape over other varieties. It is placed inside the recessed track and held down at the free end by one hand. The other hand is used to run a utility knife along the groove in the recess to split the tape into two strips of 1 inch wide tape. This split section of tape is cut from the roll and the two separate pieces are hung from the edge of the work bench by sticking one end to the edge. There are several reasons for going to this trouble. The first is that 1 inch wide tape is hard to find. The second is that it's handy to only have to purchase one size of tape to make your sticky match. In other words, your inventory management is simplified. This splitting procedure is repeated until the desired number of strips has been made.



Now another 3 foot length of tape is drawn from the roll and placed in the recessed track. The free end is attached to the take-up cylinder which, in this case, is a piece of 5 inch PVC pipe. The pipe is placed in a cradle at the end of the match board. This cradle is merely a piece of 1/2 inch plywood with a 1 inch wide groove cut in it to hold the cylinder stationary. If I were to build another sticky match board, I would make it about 6 inches longer and just cut the cradle groove into the board itself, rather than make the cradle from a separate piece of wood. The pipe in the cradle with the tape attached at the bottom is rotated until the tape has a little tension to hold it very flat in the recess. Now, the masks are put in place. The shaker is used to evenly sprinkle black powder grains along the exposed sticky portion of tape. I use powder which ranges from -10 to +20 mesh. This is roughly equivalent to 3FA commercial powder. The entire exposed sticky surface of the tape does not have to be covered with grains. It's surprising how sparse the dispersion can be without affecting the performance of the final product. A wide putty knife is then used to wipe any grains which are laying on top of the masks onto the tape. Now the masks have performed their function and can be removed.





If this is the first section of a long length of match, a length of visco is placed with one end overlapping the grains and the other end protruding out where it can be ignited. The length of the visco depends on the desired "retirement time" when the end user conforms to the age old counsel to "light fuse and retire." A section of the 1 inch wide tape is now applied over the visco and the 1/2 inch wide train of powder grains. There should be about 1/4 inch of overlap on each side of the powder train as the top strip of tape is applied. Positioning should be done carefully because you only get one chance to get it right. A section of the powder train about 1/2 inch long is left uncovered for the joint to the next section of match, if desired.

If a piece of match longer than 3 feet is desired, then the finished portion of match is rolled up on the take-up cylinder. A new section of match is started by drawing out more tape and placing the take-up reel back in its cradle. The cycle of drawing out tape, applying powder and placing the cover tape over it, is repeated until the final desired length is achieved. I seldom make a length of match more than 9 feet long but, theoretically, it should be possible to make any length needed.

A few final tips are in order before this page is finished. When using this sticky match as a leader for a shell, I insert a short length of black match or home-made thermalite in the end to maintain the fire a little longer in the vicinity of the lift powder. Where the sticky part of the leader match is not needed, I fold the sides over on the powder train to form a fuse that is much narrower than the original match width. If loading and lighting a single item at a time into a mortar, I use the match as is. When I pre-load several items at once in a mortar rack, I don't want sparks from one to unintentionally ignite the leader of its neighbor. In this case I use a single layer of paper or foil sleeve to add protection to the portion of the leader match that protrudes from the mortar. Well, there you have

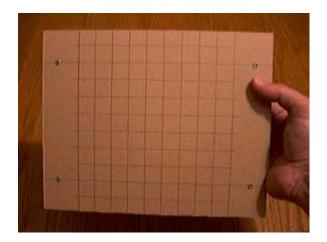
it... I have completely revealed the secret of making perfect sticky match. It's so easy, I sometimes make up a bunch just to light for fun. A 10 or 20 foot length of match going off in a split second is an impressive effect all by itself.

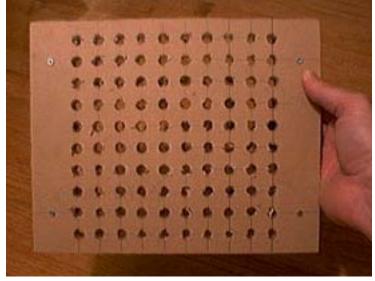
A Star Plate

Why would I want to make a star plate, you ask? I like them because they make very uniform stars. Somehow my cut stars never seem to come out as nicely as my star plate stars. Star plate stars are my favorite ones for use in roman candles. Every star making method has its pros and cons. I'll wager you will never regret having this option available when its time to make a lot of well formed stars. The inspiration for this method of making a star plate came from an article written by Bob Svenson. The following description illustrates the Svenson method using plexiglass instead of wood for the pin plate.



The starting material for this project is 3/8 inch plexiglass. It cost about \$17 for two square feet. Polycarbonate is much stronger, but is nearly double the cost from my local supplier. I also purchased two 6 foot lengths of 3/8 inch extruded plexiglass rods for \$1.35 apiece for the pins of the pin plate. Shown in this picture are two pieces of the paper faced plexiglass sheet which have been cut to identical 8 1/8 by 10 1/8 inch rectangles. One side of the protective paper facing has printed lettering and the other side is blank. The facing is removed from one side of each sheet and the two exposed surfaces are placed against each other for fastening together.





The two plates are securely fastened together with four small wood screws. This is done by drilling holes through the plates which are just slightly smaller than the screws. When screwed in, the screws will cut their own threads without requiring great effort or cracking the plexi. Next, the hole layout is drawn on the blank paper facing as shown. This is a 10 by 10 matrix of holes with 3/8 inch spacing between them. There will be a 1/2 inch border on the top and bottom and a $1 \frac{1}{2}$ inch border on the sides. You are now ready for the endurance test of your pyro devotion. You must endure the tedium of drilling 100 holes, cutting 100 pins, gluing 100 pins and enlarging 100 holes.

I'm afraid you can't avoid it. You will have to use a drill press to drill all the holes through the two plates. I wouldn't even consider trying to do this with a hand drill. Before drilling, a little experimentation will greatly enhance the likelihood that the pins will not bind in the hole plate. Using scrap pieces of plate material, drill a hole through two layers which are securely fastened together. Now check the fit of your pin material in the hole. I found that a 3/8 inch bit actually drilled a hole slightly larger than the desired 3/8 inch, probably due to



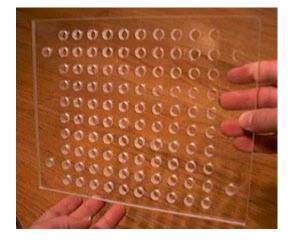
asymmetries in the drill press chuck. The result is a loose fit of the pin in the pin plate hole. You may need to experiment with a bit that is 1/64 inch (or more) smaller until a snug, but not tight fit is achieved. The holes are drilled at the intersections of the layout marks. It might save you some time centering the intersections under the drill bit if you use a movable guide rail on the drill press deck. Here's a reminder of one of the critical tips mentioned in the Svenson article. Drill every hole with the plate assemby in the same orientation on the drill press deck. Drill the holes slowly, with light pressure, especially as the bit is about the exit from the bottom of the two sheets. The friction heat will soften the plastic and lessen the likelihood of chipping as the bit exits from the material. When you finish, the attached plates should look like this.

Now, the remainder of your day is required to cut approximately 110 pin pieces from the plexiglass rounds. Using a radial arm saw with a stop block will assure that each pin is exactly the same length which, in this case, is 7/8 inches. The ends of the pins are cleaned up by standing them all up on their ends on a flat surface. Tape or a rubber band is wrapped



around the bundle of pins to gang them all together in a bunch that is approximately round. Now a vibrator sander is used to sand off the saw blade marks. Doing this on both ends of the pins, you should end up with a bundle that looks something like this picture. If ganging them all up in one bundle is too taxing on your patience, try smaller bundles of 10 to 20.

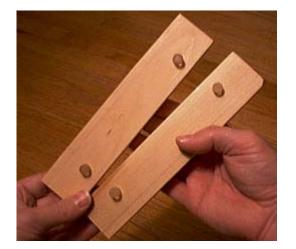
Next, the rest of the paper facing is removed and one's britches are hitched up in preparation for gluing the pins in the pin plate. (There's nothing worse than saggy britches while gluing in pins!) The original bottom plate, from which the drill bit exited during the drilling step, is designated the pin plate because it is most likely to have a few chip damaged holes in it. There are several possible approaches to gluing the pins in the pin plate. If you have the guts to try it, you can use the method illustrated in the picture. Using medium viscosity cyanoacrylate glue, a meager dab is applied inside the pin plate hole. The pin is pushed through the still attached hole plate until it is flush with the surface of the pin plate. The pin is gently rotated to evenly distribute the glue before it sets in about 10 to 15 seconds. Because the glue is more viscous than the fast setting



variety, it will not wick up the pin and weld the pin into the hole plate. This disaster is still a real possibility if you loose your concentration and apply too much glue or place it too far into the hole. The advantage of this method is that the pins are held into alignment by the hole plate. However, if you are not willing to take the risk of gluing the two plates together, separate them and do the gluing with a greater measure of peace of mind. Just remember to keep track of the original orientation of the two plates when the holes were drilled. The pins must be glued in so that when the pin plate is pushed into the hole plate, the two plates will mate in this original orientation. This is critical! You should have about 10 extra pins in case some of them are too tight or too loose. Since they are extruded, their diameter tolerance is fairly loose. Always check the fit before glue is applied.

If you didn't remove the fastening screws and separate the plates in the last step, now is the time to do so. The pin plate is essentially done unless vou desire to cut an inch off of each of the wide margin sides as recommended by Svenson. I chose not to do this because alignment of the plates during actual use is easy with a transparent pin plate. The final

phase of tedium is the enlarging of the holes in the hole plate. This step is highly dependent on the success of the previous steps. Ideally, if all the pins are perfectly aligned, the holes won't need enlarging at all. In reality, this seldom happens, and the two plates will stick a little or a lot when trying to mate them together. This is addressed by enlarging all the holes in 1/64 inch increments. Thus, the first enlargement is attempted with a drill bit that is 1/64 inch larger than the one used to drill the original holes. Each hole should be enlarged with the larger bit centered over the original hole. If this hole enlargement is successful, the pin plate should fit into the hole plate without binding or requiring a great deal of effort. Removal should also be fairly smooth. Four stand holes are also drilled in the hole plate where the original holes for the attachment screws are located. These holes are drilled with the same bit that is used for the enlarging. The finished plate should look like the picture.





If you have survived the tedium of the aforementioned steps you are now ready to make a simple stand for the hole plate. This step is a piece of cake. Simply cut two identical blocks of wood to your liking. If you want your stars to fall a long distance to their deaths. make them high. I made these from a couple scraps of 3/4 inch pine. One of them is taped in place under the wide border portion on each end of the hole plate. The stand holes you drilled earlier are now used as guides to drill a 3/8 hole in two places in each stand block. Using some of your extra plexiglass pins, glue or tap in 4 of them into the holes in the stand blocks. Finally, mark all your starplate tooling in some way to make the right orientation easy to recognize. The Svenson method of nicking off corners is a good idea for this.

Here is the completed plexiglass star plate. It's quite a beautiful piece of artwork as you can see. If your project has been successful, you may now join the exclusive plexiglass star plate owners guild and be the envy of your whole neighborhood. Be sure to send a note of appreciation to Bob Svenson for bringing the star plate within reach of the average back yard pyro enthusiast. Happy star making.

Adapt Your Ball Mill to Make a Star Roller

Any serious pyro hobbyist will want to use round stars for many of his display items. There are a few sources for purchasing these essential components, such as at some of the larger pyro events in the U.S. But the dedicated artist will eventually conclude that the art of making them himself cannot be avoided for long. Rolling them by hand is a painstaking and arduous task. This line of reasoning brings us to the conclusion that a star rolling machine will greatly enhance one's ability to produce round stars in prodigious amounts. In fact, I have heard complaints from some of my pyro cohorts that the greatest disadvantage of building such a machine is that the consumption of pyro chemicals multiplies tremendously because round stars become so easy and fun to make. Well, assuming that most of you can live with this kind of aggravate, I offer this simple idea to adapt a ball mill so that it may perform the function of a star roller machine.

CREDITS: The general concepts for building this kind of a star roller machine have been around for some time. If my memory is accurate, I believe the first person to invent them was named Fielder. Knowledge of these ideas first came to me from the description and pictures at the Connecticut Pyrotechnics Association star roller page. Another source of inspiration has been our good buddy Bob Stevenson, who previously gave me the ideas for the star plate page. He has implemented these star roller concepts in a first class, professional looking design. If any of you are looking for a great description of a stand alone star roller machine, be sure to obtain the publications of his project when it comes out.



The common way to make a star roller machine requires a DC motor with a speed controller of some kind to allow adjustment of the machine's revolutions per minute. This requires а considerable amount of expense and expertise to acquire the components and build the controller. Being the thrifty (pronounced "cheapskate") guy that I am, I looked for a way to use the drive system that was constructed for my ball mill (described in detail on another page) to serve the purpose. I reasoned that since my mill jars rotate at about the right speed for rolling stars, the adaptation shouldn't be too elaborate. Therefore, I started with the finished



ball mill pictured here. Now, the concept for a star roller is fairly simple. All you need is a rotating drum which has vibration added to the rotational motion. This greatly aids in causing the stars to cascade and mix as they roll. This star action leads to more uniformity of the finished stars due to even distribution of the solvent and star composition. The heart of the adaptation is the mounting arm which uses two 1/2 inch, self aligning, pillow block bearings to mount a shaft which supports the roller bowl. The shaft is simply a 1/2 inch by 8 inch hex head bolt which was purchased at

Home Quarters. The bearings are the most expensive part of this

assembly.



They cost about \$10 apiece at Grainger. The mounting arm is a length of pressed fiber board that is about 3/4 inch thick. The mounting arm is anchored at one end to the ball mill deck by a set of hinges. The hinges allow the arm to rotate so that the roller assembly can move up and down at the other end of the arm. These hinges are merely a set of 3 inch Stanley hinges which are available at most hardware stores. They have a little bit of play in them which allows the arm to move slightly in an undesired plane. A better choice might have been a 6 inch length of piano hinge or some other higher precision hinge which allows very little movement of



the hinge pin.

A roller wheel was cut out of another piece of pressed fiber board with the use of a router. It is mounted on the shaft so that it comes into contact with, and is driven by, the small cam wheel at the bottom. The diameter of this wheel will determine the rotational speed of the rolling bowl. With the 6 inch wheel shown, the resulting RPM of the rolling bowl is 70. If some degree of RPM adjustability is desired, roller wheels of different diameters could easily be made to accomplish this. The current RPM of 70 is about right for my wide mouth rolling bowl, but may be too slow if a smaller mouth stock pot is used for the rolling bowl.



The cam wheel is where the vibrational motion is introduced into the system. There are two very different approaches to accomplish the vibration. The simplest and easiest method is pictured here. The picture shows a 1 inch length of 5/8 inch I.D. heater hose placed over the end of the steel shaft to act as a good frictional drive surface. A one inch long, number 6 sheet metal screw is held firmly in place by the rubber hose. This forms a lifter cam which will lift the roller bowl assembly every time the screw rotates under it. The screw is easily inserted under the rubber hose by screwing it in with a screw driver. The tip of the screw should be dulled with a file so that

the screw won't try to bore into the rubber as it is screwed into place. The other method for creating vibration with this wheel is a little more elegant, but requires more effort to make. A short length of 5/8 inch wooden dowel or metal shaft could be attached to the end of this drive shaft instead of the rubber hose and screw assembly shown. This would be attached with an offset which is equal to half of the desired displacement of the roller bowl assembly. The rubber hose sheath would again be placed over the offset wheel. The resulting displacement curve for this method would be a gentle sinusoid which oscillates positively and negatively relative to the



center of the rotating drive shaft. On the other hand, the displacement curve for the lifter cam, which was described first, would contain more violent positive spikes only. It is my opinion that the lifter cam method is more efficient at producing cascading motion of stars for a given displacement, but it makes the whole roller machine want to walk away because of the more abrupt spiking of the vibration. This picture shows the spring which is used to maintain contact between the cam wheel and the roller wheel. One end is permanently anchored to the roller assembly arm

assembly an with an eye bolt. The other end is attached to

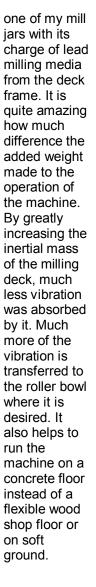


another eye bolt which slips into one of several holes which are drilled into the wooden frame of the ball mill deck. This allows adjustment of the spring tension by the choice of the hole the eye bolt is pushed into. It also allows easy disconnection of the spring when the roller arm is disengaged during milling.

The rolling bowl is a stainless steel salad bowl which was purchased for about \$6.00 at a kitchen utensil store. These bowls usually have a pattern of circular marks in the bottom which aid in locating the exact center where the mounting hole is drilled. A single nut on the hex bolt is sufficient to attach the bowl securely and allows it to be easily removed for cleaning or when not in use. These



stainless bowls are so smooth that stars sometimes tend to slide instead of roll along the surface. I have found that a little sanding with a fine grade of sandpaper will add enough texture to the surface to alleviate this problem. When using the star roller, the deck of the ball mill is elevated at one end so that the stars will stay in the bowl. This elevation is accomplished with a support that folds out from under the deck. The support is secured in the extended position by tightening the wing nuts on the bolts which attach the support to the deck frame. It is helpful to add some weight to the elevated end to stabilize the whole contraption while in use. I simply hang

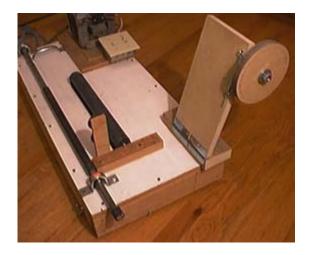


A handle has been attached to the other end of the milling deck to facilitate lifting this end of the deck to pour finished stars out of the rolling bowl.





Here is a shot of some stars being tumbled in the rolling bowl. My digital camera doesn't do a great job of stopping the action, but, hopefully, you can see that the stars bounce as well as roll when the rolling bowl is in motion. This encourages the stars to cascade over each other instead of remaining in the same position in the pile. Forcing the stars to mix around avoids the problem of larger stars gravitating to the top and continuing to grow at the expense of the smaller stars. Thus, size uniformity remains fairly good. I have added a short barrier lip around the mouth of the bowl to discourage some of the more energetic stars from escaping. It is



constructed from aluminum flashing and is held in place by a few spring clips which are easily removed when it is time to pour the stars out of the bowl. When the star rolling is done or when the machine is used for milling, the elevator stand is folded under the deck frame and the roller arm is disengaged by rotating it out of the way. This dual use of the same drive mechanism works well for me, but it is not as ideal as having two separate, single use machines. Hopefully, this project illustrates the basic principles of a star rolling machine well enough that the reader might be inspired to construct his own machine using them.

A Black Powder Burn Rate Tester

The quest for the ultimate, fast black powder seems to be an obsession with many pyros. In my case, I relinquished the quest after having achieved a reasonable, lift quality powder. However, after having become interested in girandolas, the consistency of my black powder emerged as the paramount concern. The concern motivated me to develop this simple electronic means of measuring black powder burn rates. It has been an interesting project and is simple enough that I thought others might be interested in the design.



The intent of this design was to produce a standalone timer that didn't depend on a computer or video camera to make consistent and accurate measurements of the burn times of a uniform train of black powder. A human being with a stop-watch meets the goal of standalone functionality, but consistency and accuracy is low because of reaction times of the nervous system. Therefore, I designed a simple circuit to control the contacts of a stop-watch start/stop button. Probably the biggest challenge of this approach is to find points on the circuit board in a common digital stop-watch from which to connect control wires . The picture shows a bottom-ofthe-line stop-watch purchased from MVP for \$5 US. The metal traces that connect to the switch are very small, but quite accessible. A steady hand and a fine point soldering tool are required to attach wires to these points so they can be controlled externally

by a controller circuit. This stop-watch would have served the purpose very well, but I eventually opted for a \$20 digital stop-watch because I liked the very large numbers it had in the liquid crystal display.

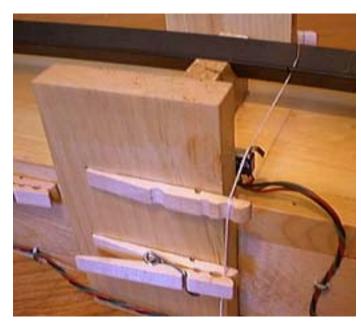
The schematic of the controller circuit will be briefly described later on. All of the parts were purchased from Radio Shack or BG Micro for less than \$18 total. The circuit uses two micros-witches to sense the start and stop times of the burning train of black powder. The switches are held with the "normally open" terminal connected to the "common" terminal by a single thread which is positioned across the powder train. When the burning powder severs the thread, the micro-switch delivers a change of state through a CMOS debounce latch to one of the inputs of a one-shot circuit. Since the 74HC123 is a dual one-shot device, one of them is used to detect the start time and the other is used to detect the stop time. Both of these events cause a one-shot to put out a 1/10 of a second pulse to a DIP relay which closes the contacts of the stop watch start/stop button. It's a very simple circuit that is relatively easy to build.



This picture shows the circuit board mounted in the enclosure box . A Radio Shack (cat. no. 276-170) proto board and project box (cat. no. 270-1808) were used at a cost of about \$6 US for both. A battery pack with four AA batteries is mounted on the outside of the enclosure for easy access.

This shot shows the enclosure box with the lid in place. The battery pack and large display, digital stopwatch are shown mounted on the top of the box. An on/off switch is mounted at the end of the box beside the battery pack.





A 4 foot length of 1 inch X 1/8 inch angle is used for containing the powder train. This is mounted on a long wooden platform made from lengths of 1 X 4. Wood mounting brackets have been made with notches in them to cradle the piece of angle iron. The angle merely rests on the bracket, but is not securely attached. This facilitates easy removal of the angle for cleaning between burn tests.

This is a close up of the place where the start thread is secured across the angle iron. For illustrative purposes, a large, white string has been used so that the placement of the thread is clearly visible. A common clothes pin secures the thread at both ends and eliminates the need to tie any knots. In actual use, a very fine, artificial fiber thread, such as fuzzy nylon, is used because it melts very quickly upon contact with the black powder flame front. A groove has been cut in the angle iron so that the thread is suspended very close to the powder train. The start thread is positioned 6 inches from the end of the angle so that the train of powder can extend beyond the start thread by about 4 inches. This gives the flame front propagation a chance to stabilize before timing of its speed begins.







The stop thread can be secured by an identical arrangement at either 45 cm or 100 cm from the start thread. The wood block which holds the stop microswitch can easily be moved by removing the two screws which secure it to the platform. This angle shows that the micro-switch has a small restraining block glued to it which limits the travel of the switch actuator. This shortens the time for the switch to register the change in state when the thread has been severed by the flame front.

A small bolt has been installed at the start end to help secure a piece of visco under it. The visco gives the operator a chance to retire a few feet before the powder train flares.

This is the complete unit from a distance. Data gathered from using it to test various aspects of the black powder manufacturing process and the effect of different kinds of charcoals will be posted below as it is taken. If there is sufficient interest in the timer circuit, it may be worth the effort to draft up a circuit board that would greatly reduce the effort to construct it. If you have an interest in obtaining one of these circuit boards, let me know.



Here is a nice picture of the tester during a burn test. It's amazing how much fire and smoke a little train of black powder can make. The burn time of the test is so brief that I barely caught it before the flame front reached the stop thread. Below is a table containing the results of my first burn rate tests. All of my powder samples were manufactured by me with 3 hours of ball milling. I used home-made charcoal made from local weeping willow. Most of the tests were conducted during a warm sunny afternoon in the shade of my garage where the air movement is kept quite still. NOTE: Tests marked with an asterisk were taken at about 8pm after the ambient temperature had cooled to about 70 degrees F. from a high of 82 degrees F. Even with this small number of data samples, it appears that test result dependence on ambient temperature is significant.

Test	Grain Size	Burn Time (sec)	Burn Speed (cm/sec)
1	-20+40	0.72	138.9
2	-20+40	0.70	142.9
3*	-20+40	0.77	129.9
		average	average
		0.73	137

Test	Grain Size	Burn Time (sec)	Burn Speed (cm/sec)
1	-10+20	0.73	137
2	-10+20	0.76	131.6
3*	-10+20	0.85	117.6
		average	average
		0.78	128.2

Test Grain Burn Time Burn Speed

	Size	(sec)	(cm/sec)
1	-4+10	0.58	172.4
2	-4+10	0.60	166.7
3	-4+10	0.59	169.5
		average	average
		0.59	169.5

More tests were done on Aug. 11, 2001 to look at the effects of different kinds of charcoal.

Weeping Willow-Branch			
Test	Grain Size	Burn Time (sec)	Burn Speed (cm/sec)
1	-10+20	0.57	175
2	-10+20	0.59	169
		average	average
		0.58	172

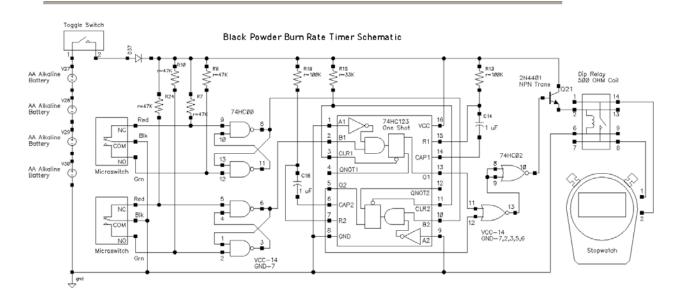
Poplar from Phil Hurley			
Test	Grain Size	Burn Time (sec)	Burn Speed (cm/sec)
1	-10+20	0.67	149
2	-10+20	0.64	156
		average	average
		0.655	153

Black Willow-Trunk			
Test	Grain Size	Burn Time (sec)	Burn Speed (cm/sec)
1	-10+20	0.59	169
2	-10+20	0.57	175
		average	average
		0.58	172

Black Willow-Branch			
Test	Grain Size	Burn Time (sec)	Burn Speed (cm/sec)
1	-10+20	0.53	189
2	-10+20	0.55	181
		average	average
		0.54	185

Schematic and Parts List Page

Just a few additional details....R15 in the schematic is listed as 33K ohms, but it is not a critical value. Another 47K resistor would work fine. The stop watch I ended up using is called a Cronus Pro Survivor which I bought for \$19.99 US. The \$5 stop watch in the picture is a Synchrotimer X-1000.



Parts list from BG Micro

- (2) SWT1023 Lever Mini Switch.....\$2.50
- (1) BAT1016 4 "AA" Battery Holder......\$0.79
- (2) CAP1019 Electrolytic 1 uf/100Vdc......\$0.78
- (1) REL1006 5/6V Dip Relay.....\$0.99
- (1) ICSHC123 74HC123.....\$0.35
- (1) ICSHC00 74HC00.....\$0.25
- (1) ICSHC02 74HC02.....\$0.25

Parts list from Radio Shack

- (1) 270-1808 Project box.....\$2.98 •
- (1) 276-170 perforated proto board......\$2.98 •
- (1) 276-1114 silicon diode, 1Kv, 2.5A\$0.49 •
- (1) 275-612 toggle switch.....\$1.49 •
- (1) 271-1347 1/4 watt 100K ohm res. 5 for...\$0.49 •
- (1) 271-1342 1/4 watt 47K ohm res. .. 5 for..\$0.49 • (1) 276-2058 - 2N4401 transistor.....\$0.49
- •
- (4) ------ AA alkaline battery......\$1.99 •

Comments and suggestions from visitor feedback:

A great idea has been submitted by "mike.j" for building the tester without the • need for an electronic controller. A drawing of the concept can be seen below. It uses three micro-switches instead of two. The first and third ones are at the start and stop points as they were in the original tester. The second switch, and its accompanying thread, may be placed anywhere between the original two. The ingenious idea is that the first switch, when its thread is burned, will close the stopwatch contacts by completing the circuit through the closed second switch. This causes the stopwatch to start counting. When the thread for the second switch breaks, the second switch opens the circuit. The third switch can then close the contacts again to stop the counting.

