SKYLIGHTER.COM'S

TURBO Pyro

10 FIREWORKS YOU CAN MAKE THIS WEEKEND

Turbo Pyro

10 Fireworks You Can Make This Weekend

by Ned Gorski

Skylighter, Inc.
PO Box 480
Round Hill, VA 20142-0480 USA

Turbo Pyro

By Ned Gorski

Published by:

Skylighter, Inc.
PO Box 480
Round Hill, VA 20142-0480
Email: orders@skylighter.com

Visit Skylighter's web site at: http://www.skylighter.com

Second Edition
September 15, 2009

CAUTION

The experimentation with, and the use of pyrotechnic materials can be dangerous. It is important for the reader to be duly cautioned. Making fireworks is inherently dangerous. Serious injury or even death can result from any number of causes, sometimes beyond the user's control. Before proceeding with these projects, be sure that you are willing to undertake these risks.

This book is dedicated to the members,
past, present, and future of

The Pyrotechnics Guild International

who have contributed so much, for so little,
to the art, craft, and science
of fireworks making.

and to

Big Nancy

for making it all possible.

Preface

There has been a need for some time for people who are just beginning their pursuit of fireworks-making, to have a simple, logical, and practical starting point, one which enables them to quickly succeed and be encouraged by their pursuits, without overly endangering themselves or those around them.

This book is designed as an introductory text to enable the reader to accomplish just that. It serves as a practical workbook to be used in making the different types of fireworks described herein. The publisher owes a debt of gratitude to all who have come before in writing about fireworks. They are too numerous to list here. Suffice it to say this book stands on the shoulders of all who have written, taught, demonstrated, or simply shared their knowledge of pyrotechnics and fireworks making. Without them, this book would never have been written.

Everything in this book has been tested. All of the formulas, procedures, techniques, tools, chemicals, and so on have all been used in the projects described herein. They all work if you use the materials and methods prescribed. Yet, these projects are basic and simple enough, that although the reader may inadvertently stray from the instructions given here, it is still entirely possible to end up with a successful firework.

That being said, we don't advise it. You will be best served, both from a safety and personal satisfaction standpoint, if you will stick to the instructions. Doing so not only maximizes your chances of success, of having your fireworks turn out right, but will also enhance your knowledge.

The thing to remember is that this book is a teacher. It has been designed to teach you to make fireworks. If you have never made fireworks before, and if you successfully complete all the fireworks projects in this book, you will be well on your way to learning the art, science, and craft of fireworks making.

But this book can never convey everything necessary for you to become a master of the elusive craft of pyrotechnics. That might take a lifetime of study and practice, mostly the latter.

What Turbo Pyro can do is get you started on a solid footing, using tried and tested methods, with relatively safe projects. If you learn these projects, you will have a good foundation in fireworks making.

It is my hope that you truly enjoy these projects, that you make and use them safely and legally, and that you want to continue forward with this incredibly satisfying and creative pursuit.

We welcome your suggestions and critiques of this book. If you find any typos or errors, please let us know.

Harry Gilliam, Publisher
Skylighter, Inc.
PO Box 480
Round Hill, VA 20142-0480 USA
540-338-3877
orders@skylighter.com
http://www.skylighter.com

Contents

Chapter 1: Using Turbo Pyro

How to Use Turbo Pyro

Turbo Pyro is a unique book. It is designed to be used in two ways:

- Printed
- On your computer.

Here's how it works. First print the whole book out and either put it into a binder or have it ring or spiral bound. This will become the workbook that you will use in your manufacturing area.

Keep the downloaded PDF file on your computer. You will need to use that document to view the many video segments of contained in this book. (It's also your backup in case you need to print the book again.)

To view the videos, you will need two things:

Adobe Flash Player: You will need to download and install Adobe Flash Player, version 9.1 or later on your computer. You can get it here free from Adobe: http://www.adobe.com/products/flashplayer/.

An Internet Connection: When you play the videos, they actually "live" on a fileserver somewhere else. They are not on your computer, nor in the Turbo Pyro document. Therefore, you'll need to have your computer connected to the Internet when you click on a video to play it.

What Is Turbo Pyro?

Turbo Pyro is an accelerated program designed to have you learning a broad range of fireworking skills, and making the associated devices in no time at all.

Ten unique and varied types of fireworks will be focused on in a comprehensive and detailed manner in one chapter each.

Right below the name of each chapter and project, you'll see how many devices you can make in that project, like this:

Chapter 5 How to Make Flying-Fish-Fuse Mines (Make 10 Flying Fish Mines)

Enough supplies have been provided in the Turbo Pyro Kit for you to be able to make exactly that number of finished fireworks.

You'll notice that each how-to chapter begins with an overview of a particular device or component, and a "Quick Start" section, which outlines the steps involved in making that device.

Then, "Detailed Instructions" will take you through the individual steps involved in making that device. Some varieties of the device will occasionally be discussed, and at the end of the chapters, more advanced projects will be described.

These are small projects. In fact, they are about as small as you can get in homegrown fireworks making. They are roughly the size and scale of consumer fireworks. The individual projects you will be working on are designed to be small, backyard scale fireworks, suitable for displaying anywhere it would be safe and appropriate to fire consumer fireworks.

The small, simple fireworks projects can lead to larger and more complex projects, though, once you've mastered the basic skills taught in Turbo Pyro.

Turbo Pyro is designed to not only enable you to make many devices, and a wide variety of them, but to learn many basic fireworking skills which will serve you for a lifetime in the hobby and art that is Fireworks.

Ten Types of Fireworks Devices You'll be Making

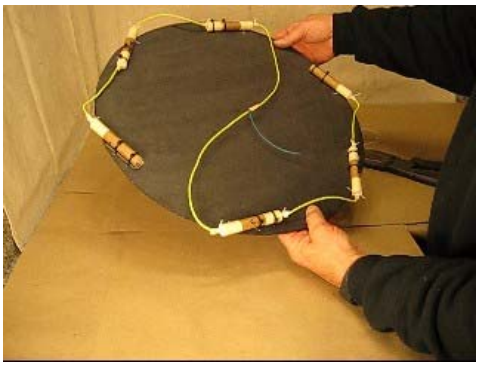
Turbo Pyro is going to take you, one step at a time, through the process of making the following ten basic types of fireworks:

3/8-Inch Pumped Stars and Star-Mines


Flying-Fish-Fuse Mines

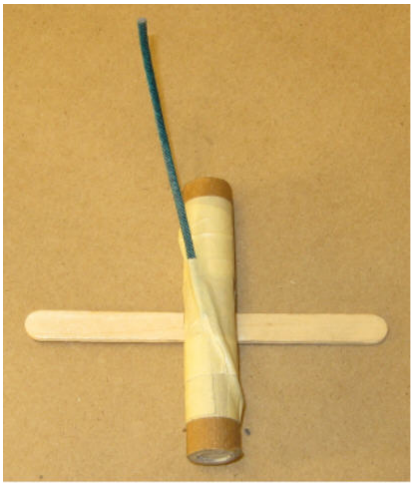

Silver-Spark Tube-Sparklers


Orange-Spark and Silver Fountains

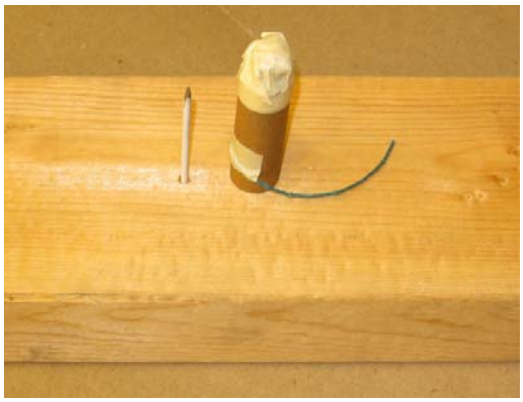



Color-Changing Wheels

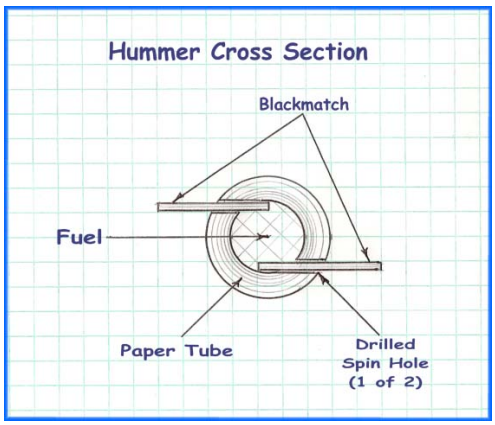

Magnum Bottle-Rockets

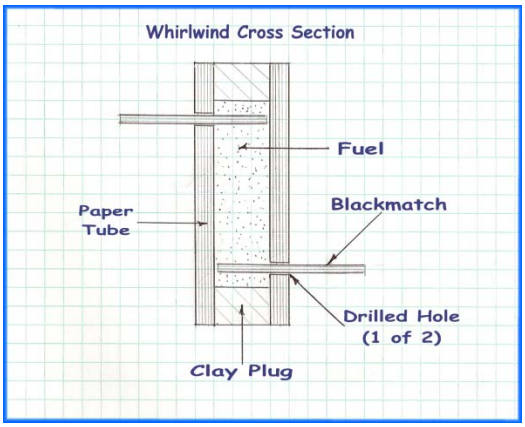



Helicopters



Stinger Missiles





Hummers and Whirlwinds

Festival-Ball Aerial Fireworks Shells

Where Do You Begin?

We'll show you exactly that, step-by-step.

In Chapter 3 you'll be directed to collect some everyday tools, supplies, and safety gear. You'll already have some of these items on hand, and the rest are readily available from local stores such as Wal-Mart.

You'll need these supplies to successfully and safely accomplish the tasks that you are about to embark on.

We'll also take a look at what is necessary to create the spaces necessary to work safely on these projects, to dry the compositions and devices, and to store them safely and securely once they are done.

Note: Safety information is the easiest type to simply gloss over and ignore. And it is the information, which can keep you from serious accident, injury, property damage, legal problems, and death. Take the safety sections seriously. You can only have fun in this art if you practice it safely, and you don't want to learn the safety lessons the hard way.

We, who are offering this information, feel a responsibility to you, who are going to use it. If you do not take certain safety precautions seriously, this work in pyrotechnics can:

- Cause great physical harm if it is not done safely
- Harm you and yours physically
- Damage your home
- Ruin your marriage and family

Here are links to the safety stories from two PGI Grand Masters with years of experience under their belts.

One story deals with a fireworker who burned himself alive and begged to be allowed to die. The other tells of one of the Grand Masters almost doing that to himself, and what he does now to prevent it.

http://www.skylighter.com/fireworks/safety-articles.asp.

In addition, you can download an excellent article, Fireworking Safety, the Law, and You, which contains an excellent project on making an indoor magazine.

Chapter 2 will describe the various specific pyrotechnic supplies, chemicals and tools that will be needed for these Turbo Pyro projects. You will be told the quantities of each supply that you will need to make the numbers of devices, which are specified in each project.

And, once you have ordered your pyrotechnic specialty supplies and you are waiting for your order to arrive on your doorstep, we'll give you a little project to be working on:

The Wheel Project requires that you prepare and assemble a simple frame on which your pyrotechnic components will be assembled. You can be working on this wheel frame once you've set up shop and while you are waiting for the pyrotechnic supplies to arrive.

And, then, in Chapters 5 through 15 we'll actually get to work on the specific fireworks projects and devices.

You will find that you get your best results if you follow these projects in the order they are presented. That's because the projects build on each other. What you learn and make in the early projects will often be used in the later ones. For instance Fountains are also used later as drivers in the Wheel project.

But, Chapter 7 describes a basic black-powder base mix, which will be used in many of the projects. And, the first part of Chapter 6 teaches you how to make 3/8-inch pumped stars.

These two components have to dry for a day or so before they can be used in the projects, so it's a good idea to begin by tackling those two components and getting them in a safe area to dry completely.

While they are drying, the projects in Chapters 5 and 8, "Flying-Fish-Fuse Mines" and "Tube Sparklers" do not need to use base-mix or stars to be completed.

So, after making the base-mix and the stars, you can get right to work on those two projects while your components for later projects are drying.

Chapter 2: Pyrotechnic Supplies You'll Need for the Turbo Pyro Projects

Now that you've decided to tackle Turbo Pyro, here is a list of the special pyrotechnic supplies you'll need to make these projects. You can't find these supplies at Wal-Mart. And most of them are not available locally at all.

So, you will almost certainly have to order them from a reputable pyrotechnic supply company. You will probably find the most economic approach will be a complete kit containing all the supplies listed below from www.Skylighter.com.

But wherever you get your supplies, make it your first order of business to order them right away. They can take one or two weeks to arrive, so you might want to order right now.

You'll also need some fairly common household supplies and tools. There's a complete list of those items in the next chapter.

The list below contains all the pyrotechnic chemicals, tools, and supplies used in the various projects in this book.

The total quantity you'll need of each item is shown. And there is a link to that product if you want to buy it from Skylighter.

Keep in mind that if you need all of the items below, it's more economical to buy them all together in the kit, than to purchase each one individually.

The price of the Turbo Pyro Kit is a fraction of what the individual items would cost if you bought them separately from anywhere.

Pyro Tools & Supplies Needed for Turbo Pyro Projects

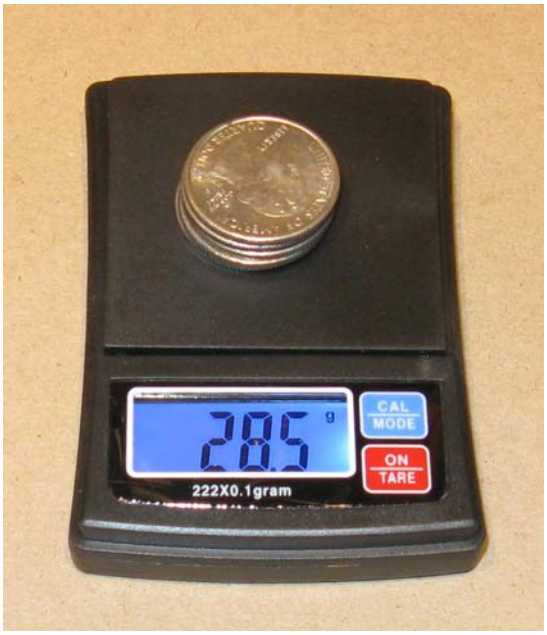
The following list of tools and supplies are provided in the Turbo Pyro Kit that you can buy from Skylighter. This is all of the special pyro supplies, tools, chemicals, fuse, tubes, etc. in the exact sizes shown in the project instructions that are needed to make all of the projects in this book.

Digital Scale

The scale weighs up to 333 grams (about 8 ounces, 1/2 lb.), has 1/10 gram accuracy is Backlit LCD Display, and weighs in grams (g), ounces (oz), or penny weight (dwt). It also has a tare function. This scale comes with batteries already installed 3-1/2" x 2-38" x 5/8" thick. Skylighter # TL5021. Quantity needed—1

It is a good idea to keep a known weight in your shop to check the accuracy of your scale each time you use it. The batteries can get low, or the scale can start to fail, and the result will be inaccurate weighing. Five US quarters typically weigh 1.00 ounce (28.4 grams), and nickels weigh 5 grams each typically.

Keep a few quarters or nickels, of known weight, in a plastic baggie so they stay clean. Check the accuracy of your scale each time you use it. That simple precaution can prevent a lot of weighing mistakes.



Checking Scale Accuracy

When you are weighing chemicals, place the mixing tub, into which you'll be putting your weighed chemicals, next to your scale.

Place an empty paper cup on your scale. Push the scale's "tare" button to set the scale to zero with the weighing cup on it.

Put the desired amount of an individual chemical in the cup on the scale, and then dump that chemical into your mixing tub.

Repeat that with each individual chemical, until all the individual chemicals have been weighed and are in your tub.

Now put another container, large enough to hold the weighed mixture, on your scale and "tare" the scale to zero again.

Pour your chemical mixture into the empty container on the scale and verify that the mixture weighs what your total batch was supposed to weigh.

That verifies that you have not forgotten a chemical, and you have weighed each individual component accurately.

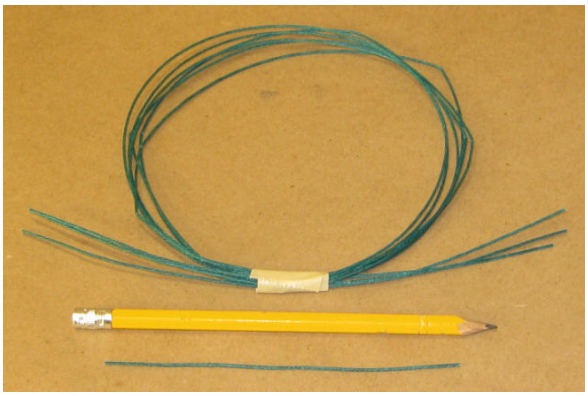
You are now ready to proceed with the other steps in mixing your composition.

Note: A digital scale may continue to “tare” after the button has been pushed, and while small quantities of chemical are added to the cup. You can add a gram or two of chemical to the cup and the scale is still displaying 0.00. It is best when weighing very small quantities of chemicals, to tare the scale to zero with the cup on it, remove the cup and add a bit of the chemical to the cup while it is removed from the scale. Then put the cup holding the bit of chemical back on the scale and adjust the amount of chemical as necessary.

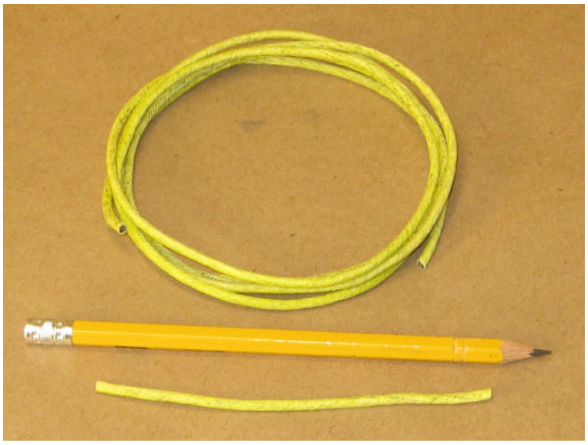
Fuses

Chinese Visco ignition fuse, 3/32-inch diameter. Green fuse, burns at about 1.7 seconds per inch. Skylighter #GN1005. Quantity needed—50 feet

Thin Chinese Visco ignition fuse, 1mm (3/64-inch) diameter. Green fuse, burns at about 5 seconds per inch. Skylighter #GN1010. Quantity needed—3 feet

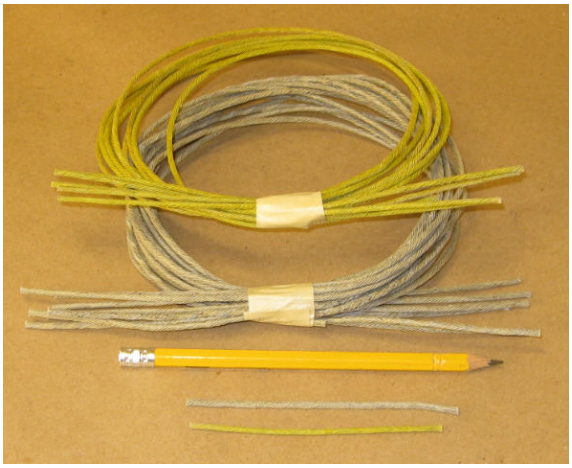


FAST BURNING Chinese Visco ignition fuse, yellow, 3/32-inch diameter. Burns at about ¼ second per inch (4 inches per second). Colored yellow so you do not use it in place of other, slower burning fuses. Skylighter #GN1100. Quantity needed—25 feet



Super-Fast Paper Fuse. Three thin strands of blackmatch, wrapped in tissue paper, 1/8-inch diameter paper fuse (1/16-inch diameter blackmatch strands). Paper-wrapped fuse burns at about 1 second per foot. Skylighter #GN1205. Quantity needed—10 feet of paper-wrapped fuse (yields 30 feet of thin blackmatch)

Flying Fish Fuse—Various Colors and Effects with varying diameters and burns at about 1.75-2.0 seconds per inch. Skylighter #'s GN1020 – GN1047. Quantity needed is 16 feet.



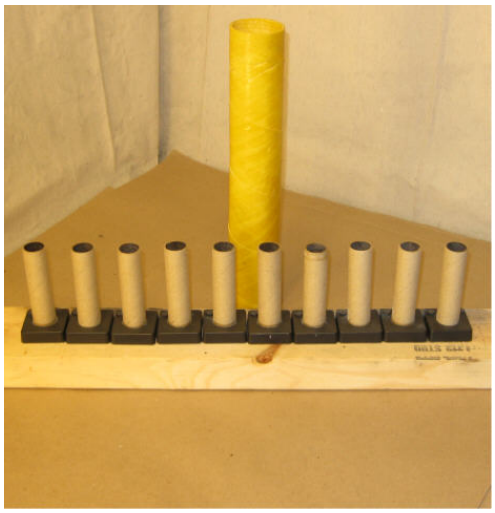
Chemicals

- Potassium Nitrate (saltpeter), white crystals. Skylighter #CH5302. Quantity needed—2 pounds
- Charcoal, airfloat. Extremely fine, grayish-black powder. Skylighter #CH8068. Quantity needed—8 ounces
- Charcoal, 80 mesh. Skylighter #CH8066. Quantity needed—4 ounces
- Sulfur, yellow powder. Skylighter #CH8315. Quantity needed—6 ounces

- Dextrin, light yellow powder. Skylighter #CH8107. Quantity needed—2 ounces
- Clay, bentonite, very fine tan powder. Skylighter #CH8078. Quantity needed—1 pound
- FerroTitanium, 40-325 mesh. 60:40 iron to titanium ratio. Gray metal alloy powder. Skylighter #CH8112. Quantity needed—6 ounces

Mortars

- Festival-Ball-Shell Mortar, 1 ¾ - 1 7/8-inch ID, fiberglass or HDPE plastic with plug. Various Skylighter product numbers. Quantity needed—1
- 3/4-Inch ID Mortars. A cardboard tube and a plastic base. Skylighter #TU2053 (tube) #PL3001 (base). Quantity needed—10 sets



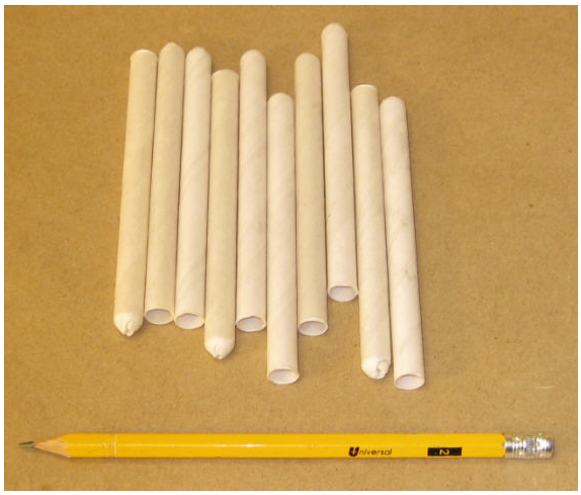
Aerial Shell Casings

Plastic Shell Casing, 1 5/8-Inch OD, #5 Shell. Spherical, two halves, one with fuse hole for Visco fuse. Skylighter #PL2030. Quantity needed—5 sets

Paper Tubes

Paper tubes, 3/8-Inch ID, 3.5-Inch Long. 1/8-inch wall thickness, parallel wound tubes. Skylighter #TU1008. Quantity needed—85

Paper tubes, 5/16-Inch ID, 4-Inch Long. 1/64-inch wall thickness, spiral wound lance tubes. Skylighter # TU2020. Quantity needed—15



Tools

Combo-Tool set for 3/8-Inch Devices. Includes star pump sleeve, ramming base, 3 spindles, hollow ramming drift, solid drift, ram-through funnel, drill-guide, and drill bit. Skylighter #TL1402. Quantity needed—1 set

You can order everything in the list above from Skylighter.com.

Order the Turbo Supplies Kit containing everything.

Go here to check out the Turbo Supplies Kit. The cost is 20-25% of what the items above would cost if you purchased them all individually.

Chapter 3: Everyday Supplies You'll Need for Turbo Pyro

Goin' Shopping

One of the very real changes you will experience when you take up the art of fireworking is the new outlook you'll have when you go out shopping.

Walk into a grocery store, a department store like Wal-Mart, or a hardware store, and suddenly you'll see things with new eyes. "Hey, I could use that colander for screening chemicals," you'll think to yourself. Or those paper plates will have a new appeal.

You'll be looking at the world around you with new eyes, pondering creative ways to use products on the shelves, or trash in a dumpster.

The following is a list of the miscellaneous household items, which will be used in the Turbo Pyro projects.

You will already have many of these items in your home or out in your workshop. You'll come up with creative substitutes for some of these supplies, or alternative products, which will work just as well.

But, if you have something like each of these items on hand before you embark on the projects, you'll be prepared to get to work and stay creatively working without having to run out to the store to get something else.

These supplies are broken down into categories:

- Kitchenware
- Office/Shipping supplies
- Craft supplies
- Sporting Goods products
- Safety Gear
- Tools
- Hardware
- Miscellaneous household supplies
- Health and beauty supplies

- Miscellaneous supplies

Knowing which category a particular item is found in will help you identify which department of a store such as Wal-Mart in which to shop for the item.

The particular use of each item will be pointed out in each project in which it is used.

Kitchenware

20-Mesh and 40-Mesh Colander Screens

These are colander kitchen strainers. On the left is a 40-mesh one, and the one on the right is 20-mesh. You'll need one of each mesh size.

How can you tell what mesh they are?

Hold a tape measure against the wire screen. The distance between wires in a 20-mesh screen is just a little smaller than one of the 1/16-inch marks. There are 20 wires per inch, so the distance between wires is 1/20th of an inch, which is a bit smaller than 1/16-inch.

With the 40-mesh colander, the distance between wires is 1/40th of an inch since there are 40 wires per inch. That distance of 1/40th of an inch is just a bit smaller than one of the 1/32-inch marks on the tape measure. Buy one colander of each mesh size.

When you are purchasing your colanders, make sure to get relatively good quality ones. Make sure the screen does not push easily out of the framed rim because you will be pushing chemicals and mixtures through the screen.

Blade-Type Coffee Mill

Cookie Sheets

You'll need at least two cookie sheets, either permanent or disposable ones. Permanent ones are a good pyro investment since they get used in a lot of projects.

A Set of Funnels

These flexible silicone funnels are ideal.

Plastic Mixing/Storage Containers and Lids

It's a good idea to have at least 6 of these.

A Set of Measuring Spoons

A Bag of 12-Inch Bamboo Skewers

1/8th-inch diameter, or slightly larger, are ideal.

Large Tri-Fold Display Board

Or some other source for pieces of corrugated cardboard at least 18-inches square.

Office/Shipping Supplies

- Hot-glue gun and hot-glue
- 2-inch wide strapping tape “for heavy jobs”
- 1-inch wide masking tape (with optional dispenser)
- Elmer’s glue
- 2 tubes of super-glue
- Rubber bands
- Thin cotton string
- Thumbtack

- One package of thin tissue paper
- One roll of brown kraft paper
- A pencil
- A black Sharpie marker
- Optional Silver sharpie marker

Craft Supplies

- Craft sticks (like Popsicle sticks)
- Assorted Wood Dowels (3/16-inch, 1/4-inch, 5/16-inch, 3/8-inch)
- Cloth sewing tape measure (optional, but pretty handy)

Sporting Goods

- Goex FFg sporting-grade black powder (Graff and Sons online, www.grafs.com; or some BassPro shops)
- Hodgdon 777 black-powder substitute (optional)

Only the Goex real black powder will work in both the Flying-Fish-Fuse Mines, and in the Festival-Ball Aerial Shells. The 777 black-powder substitute can be used in the Mines project, but not in the aerial shells.

777 powder can be found in Wal-Mart gun departments and gun stores. Goex black powder is still available in some gun stores and sporting goods stores like Bass Pro Shops. It can also be ordered online, and it will be shipped HazMat and have to be signed for by an adult.

Safety Gear

- Bucket of water
- Safety glasses (or face shield)
- Rubber gloves
- Dust masks (or higher quality respirator)

Tools

- Hand-saw and miter-box
- Cordless drill and drill bits (1/16, 3/32, 1/8, 3/16-inch)
- Mallet (non-metal/non-marring head, rawhide mallet or plastic dead blow mallet are best, rubber mallet is OK for these small projects but not very functional for larger devices)

- Pump spray bottle
- Propane torch (optional, but handy for lighting fireworks)
- Tape measure
- Flashlight
- Razor-anvil cutter (Sears Handi-Cut or similar; often found in garden centers)
- 1-inch wide paint brush
- Sharp awl
- Single-edge razor blades
- Scissors

Hardware

- Black spray paint (optional but nice)
- Duct tape
- PVC plumbing pipe cement
- 8-inch, thin, cable ties (2 packages of 20)
- 1- inch, 1.25-inch, or 1.5-inch drywall screws (10-20)
- #10 flat washers (2)
- 3/8-inch X 1.5-inch fender washers (2)
- 3-inch drywall screws (2)

Miscellaneous Household Supplies

- 1 gallon of distilled water
- Paper towels
- Thin plastic sandwich baggies
- 7 to 8 ounce sized paper cups
- Round toothpicks
- Heavy, absorbent paper plates

Health and Beauty Supplies

- Coarse-toothed comb
- Q-tips

Miscellaneous Supplies

- Two 2-foot stakes, or one 2-foot stake and a fence post
- 8-foot piece of lumber to support wheel
- 6X6-inch X 30-inches ramming post (some folks cut a section of tree-log)
- Two, 5-6-inch bottom diameter, flat-bottom tubs
- Piece of scrap plywood, approximately 2X2-foot
- Two pieces of scrap 2X4 or 1X4 lumber

There you have it, your detailed shopping list. You can get creative and find some substitutions for these items. But never forget that there's nothing like having the right tool or material at the right time to make your projects go more smoothly.

Now, get shoppin'. You're gonna need all of this stuff for the following projects.

Chapter 4: How to Make A Fireworks-Wheel Frame (Make 2 Wheel Frames)

What Is a Wheel Frame?

To make a fireworks wheel, some sort of a frame, which rotates on a central axis, must be made. The pyrotechnic "drivers" which spin the wheel round-and-round, as well as any additional effects, are attached to the frame.

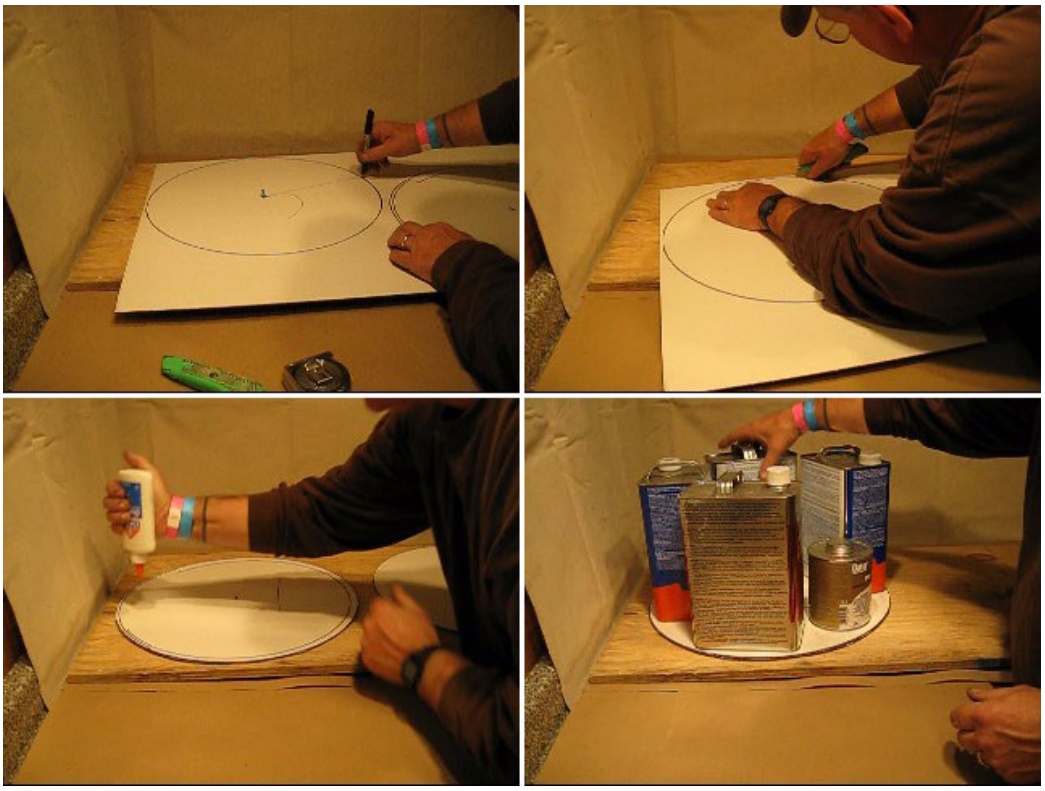
There are many ways to make frames for fireworks wheels. Corrugated cardboard frames are easy to make and widely available to anyone. But, even though they're quick, easy, and cheap to make, they won't last long, perhaps only for one use. (With a little more time and effort you can make wheel frames that will last a very long time. A couple of examples follow the cardboard frame.)

These discs can be cut out of pizza boxes (option: scrape the extra cheese off of them!) or any large, perfectly flat piece of corrugated box or other corrugated material. I made this one from a large school-project display board from Wal-Mart (about $4).

Large Corrugated Tri-Fold Display Board from Wal-Mart

Corrugated cardboard is better than non-corrugated. The reinforcing ribs inside the cardboard sandwich make it good and stiff. I cut two 18-inch diameter circles from the center section of my display board. You should glue yours together *with the corrugated ribs in each circle running at right angles to each other*. This will make a good, strong cardboard disc, about ¼-inch thick.

Weighted down overnight, your double-layer cardboard disc will be ready tomorrow for use as a wheel frame.



Marking, Cutting, Gluing, and Drying Cardboard Discs

(click image to play video)

Once it's dry, attach the cardboard wheel frame to a wooden support. You'll need a piece of any lumber at least 8-feet long, a 3-inch drywall screw, two #10 washers, two 3/8 x 1.5-inch fender washers, and a 1.75-inch long spacer tube (half of one of the 3/8-inch ID x 3.75-inch long paper tubes we'll be using in a later project). You can get all of the metal hardware at Wal-Mart or hardware stores.

Installing Cardboard Wheel Frame on a Wood Support

(click image to play video)

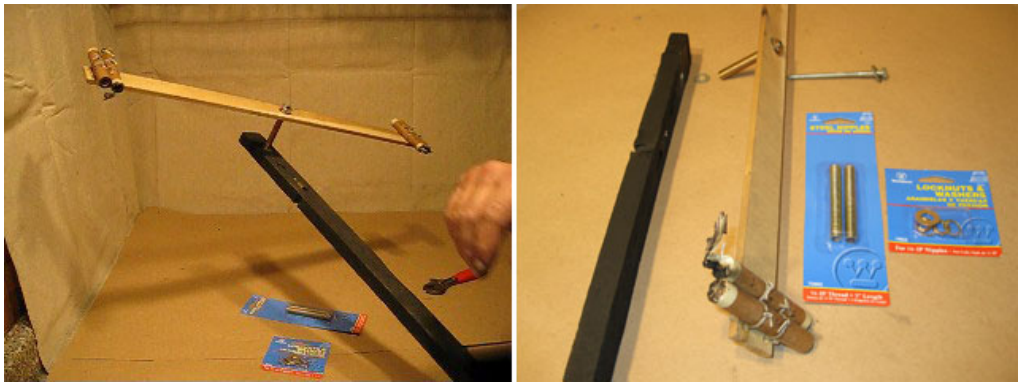
Any light colored parts will detract from the fireworks effects. So, spray-paint the cardboard and the wooden support black to keep them from being seen when the wheel display is running at night.

Note: It's easier to attach the fireworks drivers and auxiliary effects when the wheel is removed from the support. Then re-attach the wheel to the support before the wheel is to be displayed, after you erect the support or drive it into the ground.

Optional: Longer Lasting Wheel Frames

Another traditional wheel frame is simply a piece of wood with a central hub installed. A bolt is inserted through the hub to attach the frame to a support. The hub is made from commonly available lamp parts from a hardware store.

Obviously, just because you are making a fireworks wheel doesn't mean the frame has to be round. This stick-frame disproves that idea. Nice frames can be made with more than one stick, using the same hub, crossed and attached to each other to create a frame.



Wheel Frame Made from Wood Stick and Lamp Parts

(click image to play video)

Another frame can be made using an old bicycle wheel. Local bike shops are always throwing out slightly bent ones.

Keep the original wheel bearings. Replace the axle with a threaded rod from the hardware store, just small enough to pass through the bearing hubs. Tighten the doubled sets of nuts and washers until they are just snug on the wheel bearings and the wheel can still turn freely.

Make sure the new axle is long enough to be installed through a wood support and held in place with more nuts and washers. If you want to get fancy and create a “counter-rotating” fireworks wheel display, make the axle long enough that another wheel can be installed on the other side of the support.

Drivers can be attached to the wheel by drilling some holes in it and using string, wire, or zip-ties to hold the drivers in place.

Using an Old Bicycle Wheel As a Fireworks-Wheel Frame

(click image to play video)

Chapter 5: How To Make Flying-Fish-Fuse Mines (Make 10 Mines)

Crackling-Silver, and Yellow Fish-Fuse Mines

(click image to play video)

What Is a Fish-Fuse Mine?

That's really two questions: What is a mine, and what is flying fish fuse?

A mine is a fireworks device, which fires a visual and/or audible effect that burns from the ground up. This is unlike an aerial shell, which is fired high into the air, and does its thing way up high.

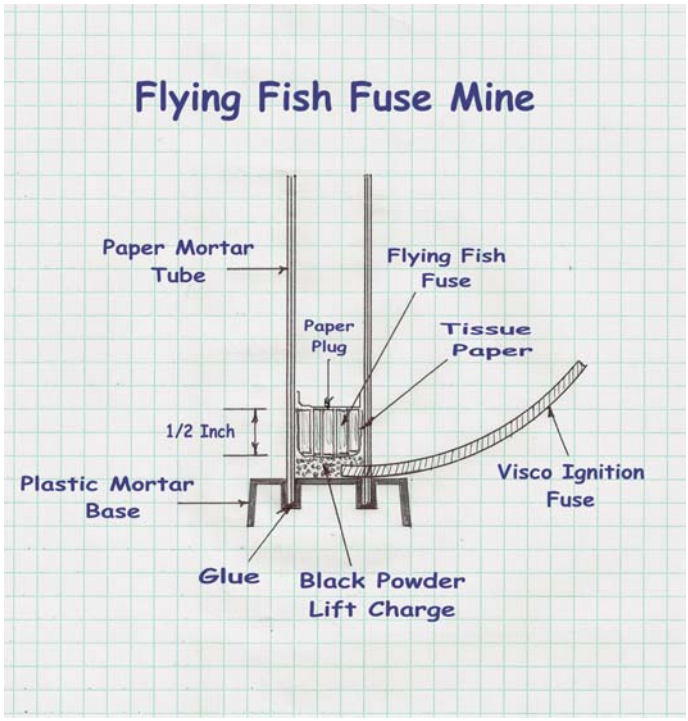
Flying fish fuse is a type of fuse, which, when cut in short lengths, appears to "swim" around in the air after it is ignited.

Mines can be large or small. The mines you make in this project are small, quiet, and suitable for use almost anywhere.

Instructions for Making Flying-Fish Mines

The Structure of a Mine

Here's a cross-section of one of the mines you are about to make.



Flying-Fish Mine Cross Section

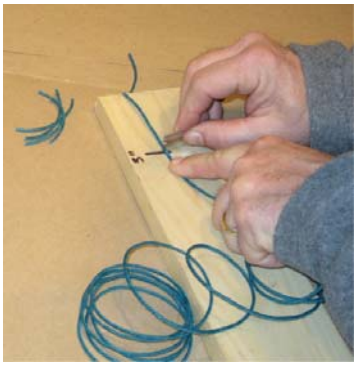
Assembling the Mortar Tubes and Bases

Spread glue into the tube-recess hole in a plastic base. Push a paper tube all the way into the recess. The tube should stand up nice and straight when the base is flat on your workbench. Two of the little tubes of super glue are enough to glue all 10 mortars together. Super-Glue dries very quickly while the next assembly steps are being accomplished. If you use Elmer's glue, allow the assembled mortar to dry 4 hours or more before use.

Gluing Mortar Tubes into Plastic Bases

Cutting the Visco Ignition Fuse into 3-Inch Lengths

It easiest if you make all 10 mines at one time. Cut off ten 3-inch pieces of green Visco ignition fuse (the 3/32-inch diameter stuff). Make a mark 3 inches in from the end of your "cutting board." Then, use a single-edge razor blade to cut the fuse into the ten 3-inch pieces.



Cutting Visco Fuse into 3-Inch Lengths

It's easier to use scissors, right? *Do not use scissors to cut the fuse.* It is much safer to use a razor blade or anvil cutters. Scissors have been known to accidentally ignite fuse.

Also, remove any black powder or fish fuse from your workbench while cutting the Visco fuse.

A good question to always have in the *front* of your mind is, "If what I'm working on catches fire, is there anything else the fire can spread to?"

If there is any flammable material around, seal it tightly in a container, such as a cooler, to prevent any accidental ignition. Assume that you WILL have an unpredictable, accidental ignition, and always operate that way. In fireworks making, forming this habit can be the difference between life and death.

Cutting the Flying-Fish Fuse into 4-inch Lengths

The flying-fish fuse is packaged either as 39-inch (one meter) lengths, or rolls of 100 feet. You will need to cut these into little, ½-inch long pieces to use in the mines.

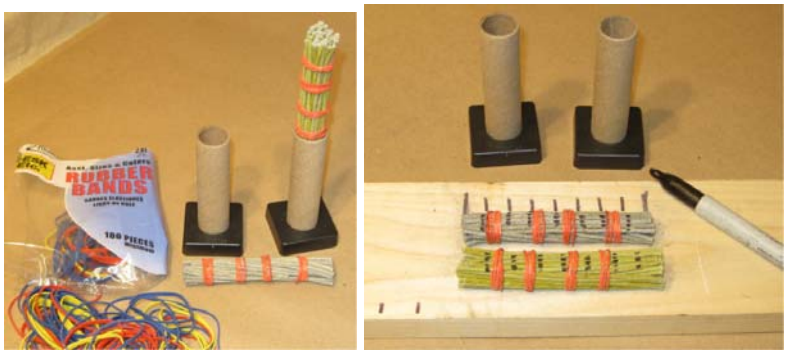
Working with pieces of fuse that small can be a pain. Here's the easy way to do it.

First, mark the cutting board every 4 inches with your Sharpie. Then, use your razor blade or anvil cutters to cut enough 4-inch lengths of the fuse to snugly fill

one of the paper mortar tubes. This bunch of fuse can be all one color, or any combination of colors.

Cutting Fish Fuse into 4-Inch Lengths, Bundling the Pieces in a Mortar

Use string or rubber bands to tie the bundles of fuse every ¾-inch. With the bundle all the way in the mortar, put a tie around the bundle right above the top of the mortar.



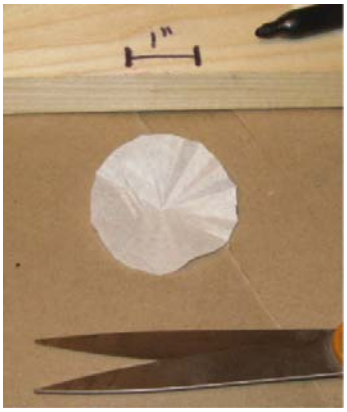
Bundling and Marking Bunches of Flying Fish Fuse

Then pull the bundle out about ¾-inch, and put on another tie. Repeat this two more times. Then remove the bundle from the mortar tube.

On the cutting board, divide the space between two of the 4-inch marks into ½-inch spaces using your Sharpie. Then line each bundle of fuse up on this section. Use your Sharpie to make ½-inch marks on the bundles. This is where they'll eventually be cut into individual "loads" for the mines.

Cutting 2-Inch Diameter Tissue-Paper Disks

One final preparatory step is necessary before a mine is actually loaded for firing. Cut some 2-inch diameter tissue-paper disks.



2-Inch Tissue Paper Disk

Assembling a Flying-Fish-Fuse Mine

Now all the materials have been prepared, and the tools are ready. It takes about a minute-and-a-half to actually load a single mine.

Ready to Load Flying-Fish-Fuse Mines

Use a pick or an awl to make a Visco fuse hole in the paper mortar tube right at the top of the plastic base. Insert one of the 3-inch pieces of Visco fuse into this hole. It should be small enough to hold the fuse securely in place.

Piercing Hole in Paper Mortar Tube, Inserting Visco Fuse

Now load the black powder lift charge. The lift charge will propel the pieces of fish fuse into the air once the Visco fuse burns in to the point where the powder is ignited.

Use three level ¼-teaspoons (3.5 grams) of Hodgdon 777 black-powder substitute. Or use a level ¼-teaspoon (1.5 grams) of Goex FFg black powder.

Warning: The black powder used in this step is the most powerful component of this device. When you finish loading a mine, put the excess powder back in its original container, and put that container in a day box or other safe, sealed storage. Keep the work area clear of all flammables that are not actually being used. Minimizing exposure to unused explosive materials is absolutely the best way to reduce the risk and consequences of a serious accident.

Loading Black Powder Lift Charge in a Mine

To load the flying fish fuse into the mortar, wrap one end of a fuse bundle with the disk of tissue paper. Then carefully insert that end of the bundle into the mortar up to the first Sharpie mark on the bundle.

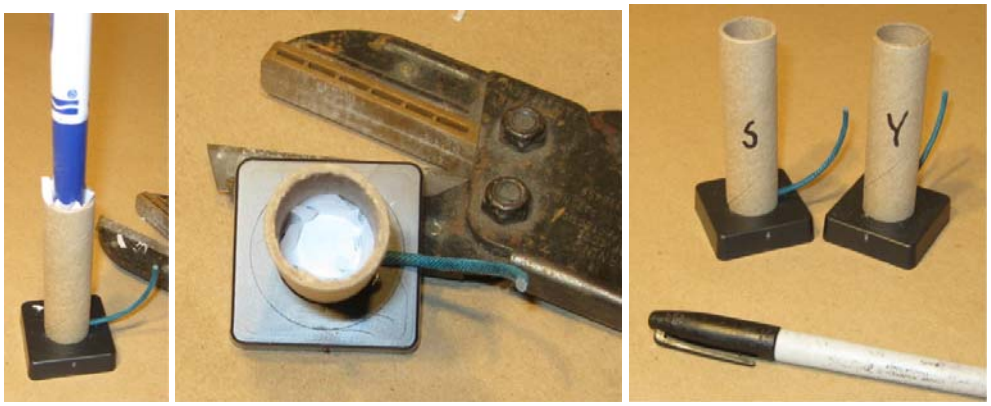
Using the anvil cutter carefully cut the bundle at that point.

Then push the tissue-wrapped fuse bundle all the way to the bottom of the mortar. A magic-marker or a 5/8-inch wooden dowel both work well.

To load another mortar tube using this same long bundle of fuse, simply remove one of the rubber-band ties, and repeat the process.

Inserting Tissue-Wrapped Bundle of Fuse into Mortar, Cutting ½-Inch Length of Fuse Off, and Pushing Fuse-Bundle to Bottom of Mortar

To finish the mine, one of the little1.5-inch-square pieces of paper is placed over the end of the paper tube and pushed evenly down to the top of the fish-fuse bundle to secure it in place. The paper will keep the fuse from falling out of your mine, and protect it from stray sparks from other fireworks.



Pushing 1.5-Inch Paper Square Down on Top of Fish Fuse, Marking Mines for Future Identification

Mark the mine with the effect it contains so you can identify it in the future.

And that's it: flying-fish-fuse mines. Light carefully and retire. Store all finished devices and pyrotechnic materials in a safe location.

How to Make a 10 Shot Flying-Fish Mine Barrage

What Is a Flying-Fish Fuse Mine Barrage?

10 Shot Flying-Fish-Fuse Mine Barrage

Traditional fireworks mines propel burning stars from the ground up into the air, and look something like this:

A Barrage of Mines Made from Colored Stars

With this project, you can make your own version of the same thing, using flying fish fuse. Not only will the pieces of fuse be propelled skyward, producing their unique effects, but they will also zip around like swarming bees.

The whole project should take you no more than an hour to assemble. It makes a beautiful fireworks display.

And after you tackle barrages made with flying fish mines, you can reuse the same mortars and reload them with different flying fish fuse or small stars.

Flying fish fuse is available in a wide variety of colors and effects. So when you've used up the kind you originally got, you can order more and experiment with the different types.

All of these materials will be assembled into a bank of mines.

If you are working with "young assistants," you may want to let them decorate the paper mortar tubes before they are glued into the bases, and before any flammable materials are present. Kids' washable markers can be used to create cool designs, or a 3.25-inch by 3.25-inch piece of gift-wrapping paper can be glued on the tube to decorate it.

Decorating Paper Mortar Tubes

You'll notice that the 3.25-inch-wide decorative-paper wrapping leaves ¼-inch of the tube exposed. This end will be glued securely into a plastic base.

Making the Mine Barrage

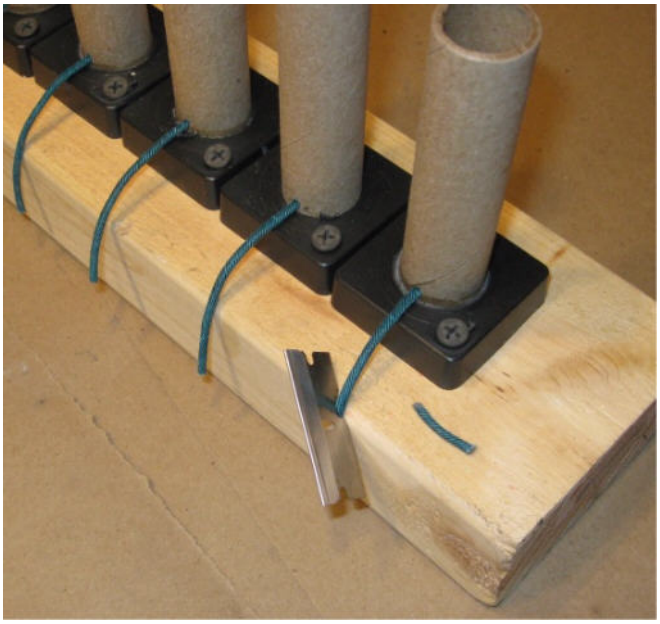
You know how it is: if one mine is good, 10 have got to be so much better.

So, here's what to do. Join a line of mines on a board, all linked together with one fuse, so that they fire one after another right down the line, sort of like a multi-tube repeating firework device.

First, drill a hole in one corner of each plastic mortar base, and screw the mortars to a scrap piece of 2x4 board. Pierce the bottom of each paper tube, and insert a piece of Visco fuse into each mortar.

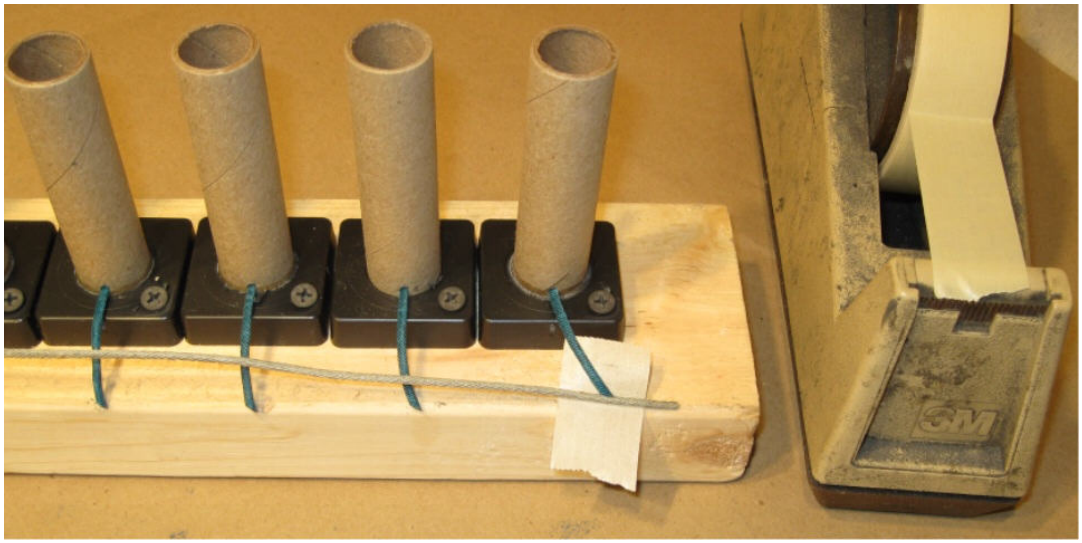
Attaching Mortars to 2x4 Board

Next, slice each piece of Visco fuse with a razor blade. Make sure each fuse is the same length, and cut the end on an angle to expose as much fuse powder as possible for good ignition.

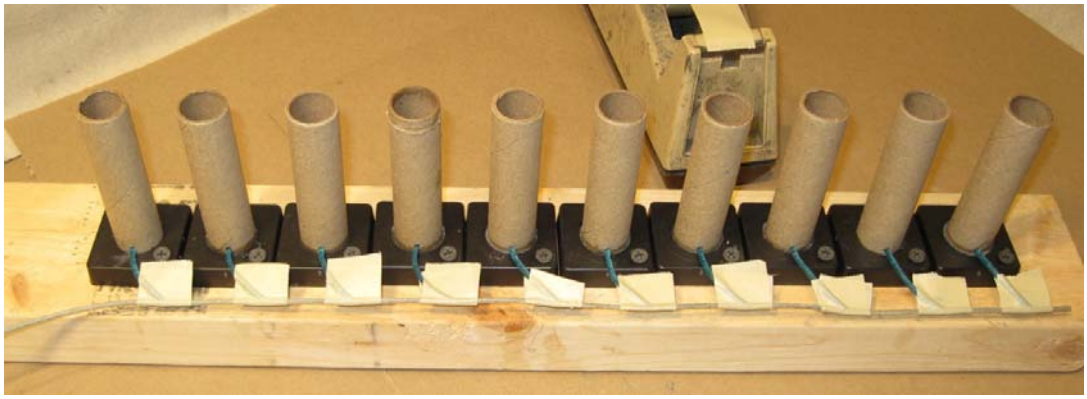


Cutting Visco Fuses on Angle to Same Length

Use masking tape to tie the angled-cut end of each Visco fuse to a length of the flying-fish fuse, or yellow fast Visco fuse, being used as a “barrage chain fuse.”



Tape End of Visco So It Touches Barrage Chain Fuse



Masking Taped & Fused Flying Fish Mortars

Load each mortar with the black powder lift charge, ½-inch fish fuse bundles, and paper plug as you did with the single mines. Try alternating the different colored/effects fish fuse loads.

10-Shot Fish Fuse Mine Cake, Loaded and Ready to Light

10-Shot Flying Fish Fuse Mine Barrage

(Click Image to Play Video)

Chapter 6: How to Make Pumped Stars and a Star Mine (Make 10 Pumped Star Mines)

Charcoal Streamer Star Mine

(click image to play video)

Instructions for Making Pumped Stars and Using Them in Mines

Chapter 5 shows you how to make mines using flying-fish-fuse.

This project shows how to make a different sort of mine using 3/8-inch pumped stars instead. And the same batch of stars you use for the mines are used in other projects in this book such as rocket headings and aerial shells.

The construction in this project is the same as fish-fuse mines, except the mortars will be loaded with homemade stars instead of fuse.

Both types of mines look great in any backyard fireworks display, because the effects are quite different from each other. The fish-fuse pieces go up and then they start darting around like bees or fish. The star-mines shoot straight skyward and leave a vertical spark trail behind each star.

Different Ways to Make Fireworks Stars

Fireworks stars can be made various ways. Even though each method has advantages and disadvantages, there really is no “one best way” to advise you to make stars. Each has its place in fireworks making, and over time, if you use stars in your fireworks, you will probably find each method useful, depending on what you are want to accomplish.

There is the “cut star” method, sort of like slicing and dicing dough. Lots of stars can be made very quickly and cheaply this way, but they will limited be one color or effect.

There are stars that are made by pressing or molding composition into small tubes: box stars and go-getters, for instance.

Other stars are made into round balls, starting with a core and rolling layers of star composition on it, enabling you to have a star that can change color several times. Round stars can be made quickly, in virtually any size, and with unlimited color/effect changes. But to make any quantity at all, you need a star-rolling machine, something that can be expensive or hard to find, unless you can make it yourself.

Pumped stars are made with a piston and cylinder to turn out individual stars, or with star-plates. A star plate is basically a gang-pump, which pumps numerous stars at once.

3/8-Inch Brass Star Pump and Star Plate

There are several other types of stars as well. But in this project you’ll learn to make pumped stars. You will use a star pump to quickly turn a small batch of star composition into about 160 individual, uniform, cylindrical stars.

This method comes in handy for making quick stars for testing, or for small projects. Pumped stars are usually made in a single color or effect (although it is possible to "sandwich" two effects).

You make these stars by dampening a star composition, compacting the comp in a metal sleeve, and then "pumping" out small cylindrically shaped stars.

One great thing about pumping stars is that you use relatively dry composition. The stars can be pumped and primed one day, dried overnight, and used in devices the next day. This is a huge advantage because it really speeds up your fireworks projects.

Which Type of Stars Should You Make?

For mines, you can use almost any kind of star color or effect. It really all depends on your personal preferences. But for this project a tried-and-true, fast-burning, charcoal star formula will be used.

The batch below is enough to make about 160 stars. You'll need 40 stars for this project (10 mines), and you'll still have enough stars left over for the rockets and aerial shells in the other Turbo Pyro projects. And remember you always need a few extra for star testing, breakage, etc.

Charcoal-Star Formula (makes about 160 3/8x3/8-inch stars)
Shimizu's Chrysanthemum 8 Charcoal Star

Chemical	Percentage	4 Ounces	115 Grams
Potassium nitrate	0.49	1.96 ounces	56 grams
Charcoal, airfloat	0.40	1.6 ounces	46 grams
Sulfur	0.06	0.24 ounce	7 grams
Dextrin	0.05	0.2 ounce	6 grams
Total	1	4 ounces	115 grams

Dampen the composition with +10% distilled water. That's 0.4 ounce of water by weight or 11.5 grams.

Note: If you have all the Turbo Pyro Supplies listed in Chapter 2, then you have enough materials to make two batches of stars and prime.

Grinding Chemicals

First, verify the potassium nitrate and sulfur are fine enough to easily pass through a 40-mesh screen. If either of them won't, pulverize each individual chemical in a blade-type coffee mill until it will easily go through the 40-mesh screen. If you need to grind chemicals, do not mix them when milling or grinding.

Pulverizing Chemical in a Blade-Type Coffee Mill

(click image to play video)

Weighing and Mixing the Chemicals

Weigh each chemical individually into its own paper cup. Then combine all chemicals into one cup. Tare the cup and weigh it. Make sure the total weight is the same as what is shown in the formula. This verifies no mistakes were made during the weighing.

After confirming the weight, pour the chemical mixture into a mixing tub. Snap the lid tightly on the tub, and holding the lid on tight, shake the tub to mix. In fireworks making this mixture is now called a chemical "composition" or "comp."

Weighing a Chemical for a Batch of Stars

(click image to play video)

Screening the Mixed Composition

Next pour the comp out of the mixing tub, and screen it twice. Do this outdoors using a 20-mesh screen to break up any clumps, and to more thoroughly mix it.

Screening the Chemical Composition

(click image to play video)

Dampening the Composition—Pay Close Attention

Dampen the composition by spraying water into the mixing tub as you knead the mixture with gloved hands. Dampen until it just stops being free-flowing.

Put the tub and composition on your scale and tare it. Spray water into the tub until you have added the 0.4 ounce/11.5 grams of water. The amount is critical.

But be careful.

Too much water and your stars may never dry. Too little and they will not hold together. Getting the water just right cannot be overemphasized. Over-watering is the single problem you are most likely to have in making these stars.

Too much water and the composition gets sticky and hard to work. The stars take longer to dry, and may never dry completely in their centers.

What happens is the damp composition in the middle of the stars gets completely surrounded by an impermeable, hard, dry shell, and the water cannot evaporate out. That's called "driven-in" moisture. You will have to throw that batch away. Wasted time, wasted money.

All right, then. So how much is too much? How do you know when you have just the right amount of water?

Well, the short answer is: "experience." But we can make it a little easier for you to tell. Here are some other ways to gauge comp wetness.

First, stick to the formula given above. Use the exact ingredients specified and follow the weighing and measuring instructions precisely. If you change the ingredients or the proportions, all bets are off.

WEIGH the water, just like the instructions say. Remember, we have done this before and this is a tried and tested formula and process. If you stick to the water weight given in the formula, you should be fine.

If your hands/gloves are really dirty after mixing, the comp is probably too wet. That's because there's more water than the comp can hold, which makes your hands wet, which picks up the charcoal.

Dampening, Screening and Mixing the Composition

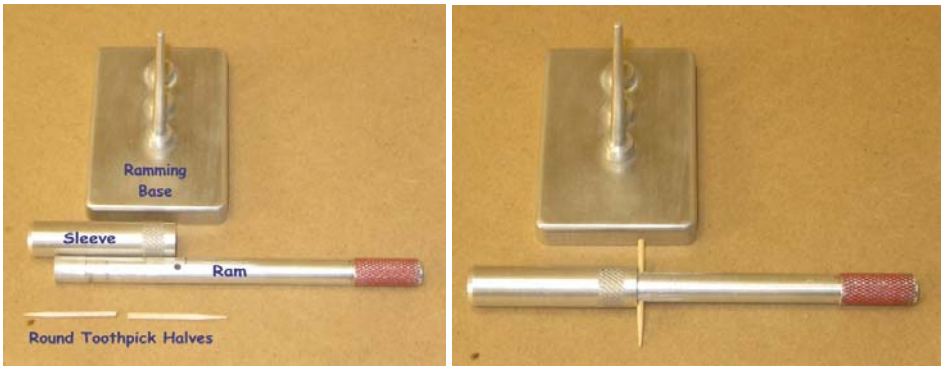
(click image to play video)

Pumping 3/8-Inch Stars

Pumping stars requires the correct tools and skills. You'll need a mallet, a ramming post, a solid base on which to pump the stars, and a star pump.

To make the stars you will be "ramming" (hammering to compact) the composition in the star pump. Hand ramming (vs. the more precise process of using a hydraulic press) is a skill that takes practice. You'll get more productive at it as you do it more.

To pump the stars using your Combo Tool, break a round toothpick in half and stick it in the hole in the solid rammer. Slide the rammer down into the aluminum sleeve until the toothpick pin stops at the top of the sleeve. This will leave an empty space about 7/16-inch deep.



Assemble the Star-Pump

The purpose of the toothpick spacer is to help you make finished stars that are consistently the same thickness.

Plunge the pump into the damp star composition several times to fill the empty space. Ram the pump into the composition the same number of times, and try to use consistent pressure when doing this. This will help make your stars the same thickness. Place the open end down on a hard ramming block (your Combo Tool's aluminum plate is great for this).

Remove the toothpick pin. Then ram the star with 3 or 4 blows of the mallet. Again, try and use a consistent number of blows and pressure.

If you forget to remove the toothpick pin and ram the star, it will break the toothpick. But this won't damage your pump. Simply remove the ram, push the remains of the toothpick out of the hole, insert a new toothpick half, and press on.

After ramming you'll have a star about as long as the ram's diameter, 3/8-inch in this case. Simply push the star out of the sleeve with the ram.

Repeat this process to pump each individual star.


Hand Ramming Pumped Stars

(click image to play video)

Priming Stars

To ensure reliable ignition of the stars and that the whole surface of each star takes fire quickly, prime them with a black-powder prime composition right after you make them.

Black-Powder Star Prime (enough for one batch of stars

Chemical	Percentage	0.7 Ounces	20 Grams
Potassium nitrate	0.75	0.53 ounces	15 grams
Charcoal, airfloat	0.15	0.1 ounce	3 grams
Sulfur	0.1	0.07 ounce	2 grams
Dextrin	+.05	0.04 ounce	1 gram
Total	1.05	0.74 ounce	21 grams

Place a batch of damp, pumped stars in a plastic bowl. Spritz the stars with water lightly. Swirl the stars in the bowl while you dust a teaspoonful of the prime composition on them. Keep swirling until the stars take up all the prime.

Repeat these steps, without getting the stars too wet, until a 21-gram (0.74 ounce) dose of the prime has been applied to the whole batch of stars.

Spraying Stars with Water, and Dusting with Black Powder Prime

(click image to play video)

Drying Stars

Warning: Always dry your stars away from people and property. Drying stars have been known to spontaneously combust. Or, if a stray spark were to ignite them, you could have a fast and massive flash fire. To figure out the safest place to dry your stars, assume they will catch fire—now where would you want that fire to happen?

These pumped stars do not have much water in them, so they dry quickly. They will dry best in a warm, dry, shady location with moving air.

For best results, place the stars on a screen so that moving air can reach all sides of the stars. But you can leave the stars on a paper plate in a warm, breezy, shady, safe location, and they will dry quickly there. Do not dry them in the sun.

How do you know when your stars are completely dry?

Several ways: They don't crumble in your fingers when you squeeze them hard. Or, put some in a sealed Ziploc baggie in the sun, and there's no condensation in the baggie after a half hour.

Many folks use a food dehydrator to dry stars. This is fine.

But if you use this method, do it remotely using an extension cord, away from any people or property you care about. Because this is an electric device, it can malfunction and cause a fire.

Line the trays of the food dehydrator with fiberglass screen to prevent stars or flammable powder from falling through and landing on the electrical element. Your dryer can be modified to reduce the current and heat in the electrical element. Adding a little computer (or "muffin") fan to the top of the unit can increase air circulation and reduce drying time.

Long term, if you get serious about making fireworks stars, a drying chamber is the best. A drying chamber will dry your stars overnight. There's a project on the Skylighter web site for making an excellent drying chamber.

Drying Stars on a Paper Plate, a Screen, or in a Food Dehydrator

(click image to play video)

Making a Mine with Pumped Stars

Small mines are easy to make using these pumped stars, and the same mortar, Visco fuse, and lift powder you used in the Flying-Fish-Fuse Mines project in Chapter 5. You can almost repeat that same process.

Once you have loaded the lift powder and fuse in each mortar, push four of the 3/8-inch stars down into a 2-inch diameter piece of tissue paper as they are inserted into the mortar. Shove them all the way down on top of the lift powder. Then shove a 1.5-inch square of paper down on top of the stars to seal them. This last step prevents sparks from other fireworks from prematurely igniting your mines.

You can create a 3-shot fan of mines by mounting the mortar bases on a 2.25-inch square piece of ½-inch thick plywood spacer, on a piece of 2x4, as shown below.

Poke holes in the bottom of the tubes and run Visco fuse or fast, yellow-Visco fuse all the way through them so they ignite one after another.

Loading and Firing a 3-Shot, Fan-Shaped, Star-Mine Repeater

(click image to play video)

Note: The “titanium-charcoal” stars mentioned in the video were a batch made in another project. There is not supposed to be any titanium in the formula above.

There they are, homemade pumped stars and star-mines. Light carefully and retire. Store all finished devices and pyrotechnic materials in a safe location.

Chapter 7: How To Make Black-Powder Base Mix (Make enough Black Powder for all projects)

What Is "Black Powder Base Mix?"

You'll notice if you glance through the projects in this book, many of the fireworks devices use the same black-powder base mix. This mix contains the three components of traditional black powder: potassium nitrate, charcoal, and sulfur.

Sometimes this mix is used as is. Often it is slightly modified by the addition of other chemicals, serving as the starting point or basis for different formulations—hence "base mix."

Your projects will be less complicated, and you'll really speed up the process if you make the base mix for all the projects at one time in advance. Again, to emphasize, if you make up your base mix now, you will be able to complete the Turbo Pyro projects in a fraction of the time it would normally take.

Warning: You're about to make one of the most common, yet powerful, pyrotechnic compositions used in fireworks. Observe all safety steps as you go along:

- Minimize the exposure of this composition to any possible ignition source whenever possible
- Store the mixture safely
- Have a healthy respect for it

These will go a long way toward keeping you alive and well.

Warning: Watch what happens when just one teaspoonful of this black-powder base mix is laid out in a line 8-inches long, and ignited. You can see that if you are in close proximity to a large quantity of this powder when it ignites, you will not have time to escape the fireball. Advance preparation is the only way to avoid serious mishaps when working with energetic compositions. You will never be able to outrun an accidental pyrotechnic ignition.

One Teaspoonful of Black-Powder Base Mix Being Ignited

(click image to play video)

How Much Base Mix to Make?

24 ounces (680 grams) of base mix will be enough to complete each project if you make the number of devices specified in each project.

So, to make a 24-ounce batch of the black powder base mix, you will need the following quantity of each chemical:

Chemical	Parts	Ounces	Grams
Potassium nitrate	75 parts	18 ounces	510 grams
Airfloat charcoal	15 parts	3.6 ounces	102 grams
Sulfur	10 parts	2.4 ounces	68 grams

These three components are ground fine and mixed.

Milling the Potassium Nitrate and Sulfur

A simple method for grinding individual chemicals very fine is to use a small blade-type coffee mill. Never grind mixtures of chemicals in a coffee mill because they can ignite or explode.

The coffee mill can efficiently grind 3 ounces of the potassium nitrate at a time, and 1.2 ounces of the sulfur at a time. It only takes 10-20 seconds for each batch. So, you should mill six 3-ounce batches of the potassium nitrate and two 1.2-ounce batches of sulfur.

Make sure they are fluffy fine. Store these individual milled chemicals in their own plastic baggies, segregated from the unmilled chemicals.

Blade-Type Coffee Mill Grinding Individual Chemicals

(click image to play video)

Note: Small inexpensive coffee mills like those from Wal-Mart can overheat if you run them too long. Once they overheat and stop working, they won't work again. Mill one or two batches of the chemical at a time. Use short 5-10 second pulses, and let the mill cool down before milling any more.

Airfloat charcoal is fine enough to be used as is, so you don't need to grind it in the coffee mill.

Mixing Black-Powder Base Mix Composition

You should now have a tub of 3.6 ounces of airfloat charcoal, 18 ounces of milled potassium nitrate, and 2.4 ounces of milled sulfur. You'll use these three chemicals to make the 24 ounces of black-powder base mix. But it's a little cumbersome working with batches that large. So, first make three 8-ounce batches.

8-Ounce Batch of Black Powder Base Mix

Chemical	Percentage	8 Ounces	227 Grams
Potassium nitrate	0.75	6 ounces	170 grams
Airfloat charcoal	0.15	1.2 ounces	34 grams
Sulfur	0.10	0.8 ounces	23 grams
Total	1.00	8 ounces	227 grams

Weigh out the individual chemicals for an 8-ounce batch into their own paper cups. Then dump them into a plastic mixing tub. With the lid on tight, shake the chemicals to mix them together, holding the lid down while you do.

Then open the tub, and pass the mixture through a 40-mesh kitchen screen or colander into another tub. Work the composition through the screen with your gloved hand.

Cap that second tub and shake the contents again. Repeat the shaking and screening process three times to ensure the chemicals are completely mixed.

Note: Mixing and screening this chemical mixture is a dirty process. It's best done outdoors wearing a dust mask. Also, this is now a very flammable, potentially explosive composition and needs to be treated with respect, keeping it away from all sources of sparks and flames.

Weighing and Screen-Mixing Chemicals for Base Mix

(click image to play video)

Dampening, Granulating, and Drying Base Mix Composition

Once again, do this outdoors to minimize dust contamination and wear gloves. Spray water into the base-mix composition, and work the water into the powder with your hands.

Spray one ounce of water (either a fluid ounce by volume or an ounce by weight--they're both the same) into the 8-ounce batch of powder. Work it in with your hands. Then press the dampened composition through a 20-mesh screen or kitchen colander.


Dampening Base Mix with Water, Working It In with a 20-Mesh Screen

Spread the dampened composition out evenly on a kraft-paper lined tray. Place in a safe, warm place to dry, ideally outdoors. In a warm and lightly breezy location the mixture will be dry in a few hours. But, if there is too much wind, the paper and mix will fly off your tray, ruining your hard work.

Drying Base Mix on a Paper-Lined Tray

(click image to play video)

Once it is dry, work the powder through the 20-mesh screen one more time to break up clumps. Then put it into a sealed plastic container. Store this container safely away from any source of heat, sparks, or fire.

Your black-powder base mix is now ready to be used in various projects: fountains, wheels, rockets, and some special effects.

Chapter 8: How to Make Tube Sparklers (Make 15 Sparklers)

Non-Metal Tube Sparkler & Ferro-Titanium Tube Sparkler

(click image to play video)

Instructions for Making Tube Sparklers

What Is a Tube Sparkler?

There are two basic types of sparklers: dipped sparklers and tube sparklers.

Dipped sparklers are made by dunking a wire or wooden stick into a wet composition once or more times to create a sparkler coating on the handle.

Tube sparklers are made by filling a tube with a dry pyrotechnic composition. The tube can be attached to a wood handle for easy and safer handling as it burns. This type of sparkler is much quicker and easier to make than a dipped sparkler since it requires no drying before lighting it.

Tube sparklers can be made with or without a spark-producing metal in the composition. If they are made without a metal, they can be used as a hand-held torch, called a portfire, for lighting fireworks during a display.

They can also be assembled in patterns on a framework to create pictures in fire. In that application they are called lance, and the picture is called lancework.

Here's a modified version of a portfire formula from Weingart's Pyrotechnics.

Portfire Formula

Chemical	Percentage	4 Ounces	115 Grams
Potassium nitrate	0.72	2.88 ounces	82.8 grams
Airfloat charcoal	0.02	0.08 ounces	2.3 grams
Sulfur	0.26	1.04 ounces	29.9 grams
Total	1.00	4 ounces	115 grams

Note: All chemicals are fine enough to pass through a 40-mesh screen. If the chemicals are more finely ground than that, the sparklers will burn faster.

To get sparks, add 20% metal to the above formula. In this project we'll be using ferro-titanium.

Sparkler Formula

Chemical	Percentage	Ounces	Grams
Portfire mix	1.00	4 ounces	115 grams
Ferro-titanium	+0.20	0.8 ounces	23 grams
Total	1.20	4.8 ounces	138 grams

Note: Steel, titanium, and other metals can be used for different types of sparks.

Screening Chemicals

Screen a little more potassium nitrate than you'll need (see formula above) through a 40-mesh screen or kitchen colander. Screen the sulfur into its own container.

Note: Use a clean cup and bowl for each chemical to prevent cross-contamination of the chemicals.

The airfloat charcoal and metal do not need to be screened because the charcoal is already fine enough, and the metal should never be put through a screen.

Screening Potassium Nitrate

(click image to play video)

Weighing Chemicals

First, weigh each individual chemical into its own clean cup.

Note: I have noticed that when my small digital scale is turned on, if a cup is placed on it and the scale then “tarred” to zero, and if a small amount of chemical is sprinkled into the cup, that the scale will continue to tare itself to zero occasionally, and not register the weight of the small amount of chemical. If your scale has this problem, turn the scale on, put a cup on it, tare it to zero, then remove the cup, put a small amount of the chemical into the cup, and then put the cup back on the scale. The scale should then read correctly.

Mixing the Composition

Run the three non-metal chemicals together through the 40-mesh screen into a plastic mixing tub. Do this 3 times. Cover and shake the tub between screenings. This thoroughly mixes the chemicals.

Screen-Mixing the Sparkler Composition

(click image to play video)

Note: Never put metals through your screens. First, there is almost never a need to. Second, they are likely to clog the openings and contaminate screened chemicals in the future. Instead, after the other chemicals are mixed, put the metal into the tub, cover it, and shake it to mix the metal into the composition.

Weigh the complete composition to verify it weighs what it is supposed to (see formula above) and to be sure no mistakes were made during the previous steps.

Loading Sparkler Composition into Paper Tubes

Now it's time to load the composition into the paper tubes. I use 5/16 ID x 4-inch long "lance" tubes, which come with one end closed. One 4-ounce batch of composition will fill 15 lance tubes. The "rod and funnel" method is an easy way to accomplish this task.

Push one of the 4-inch paper tubes against a tabletop to flatten and close the end.

Insert the tube into a snugly fitting funnel. Then insert a wood dowel, smaller than the tube ID by about 1/16-inch, through the funnel and into the tube.

Place a heaping teaspoonful of the sparkler composition in the funnel. Then lift and drop the dowel in small increments, compacting the composition, until the tube is full.

Note: While the tube is being filled, be sure you put the lid back on the tub of composition to limit the amount of exposed flammable powder at any given time.

Using Rod and Funnel to Fill Paper Tube with Sparkler Composition

(click image to play video)

One of the 4-inch tubes filled with non-metal portfire composition burns for about 2 minutes. Filled with the metal sparkler composition, it will burn for about 75 seconds.

For a larger, longer burning sparkler, a homemade 3/8-inch ID tube, 11-inches long is easy to make and fill.

Roll a half-sheet of copier paper on a 3/8-inch wood dowel and glue the edge down with Elmer's glue. Remove the tube from the dowel and close one end of the tube with a piece of masking tape.

Now fill the paper tube with composition using a larger funnel and a 5/16-inch dowel rod.

Rolling a Long Paper Tube, Filling It with Sparkler Composition

(click image to play video)

These 11-inch tubes hold about 29 grams of composition. A non-metal sparkler made with one of these tubes will burn for about 5 minutes; a sparkler with metal composition burns for about 3 minutes.

Attaching Fuse and a Handle to the Tube Sparkler

A couple of final steps will have the sparkler ready to take outside and light.

Tube sparklers can be lit directly with a match or propane torch. But, it is safer to attach a 3-inch piece of Visco ignition fuse to the open tube end with a piece of masking tape.

For a wooden handle, insert a sharp bamboo skewer into the bottom end of the sparkler tube.

Note: I never cut fuse with scissors. Scissors create friction when they cut and can cause an accidental ignition. I always cut my fuse with a sharp razor blade or a pair of anvil type cutters.

Attaching Fuse and a Handle to the Sparkler

(click image to play video)

Conclusion

These are impressive homemade sparklers that are really fast and simple to make. Let's clean the shop and take some out and fire 'em up.

These sparklers do emit hot metal sparks, and they drop some molten slag as they burn. Children should use these only with very close adult supervision. Eye

protection is an excellent safety precaution. It is best to not breathe the smoke from sparklers. So hold them downwind as they burn.

One interesting variation on these tube sparklers is to use some coarse spherical titanium in them instead of ferro-titanium. The titanium drops fall from the sparkler for 6-8 feet, and then burst into impressive popping sparks.

You can use sparklers made with spherical titanium to make a fireworks waterfall. Just install them on a horizontal board erected 8-10 feet high and fuse them all together. This is what they look like when they are ignited.

A Tube Sparkler Made with Coarse Spherical Titanium Metal

(click image to play video)

Chapter 9: How to Make Fountains (Make 10 Fountains)

Two Kinds of Fountains in This Project

The projects in this chapter utilize the black-powder base mix you made in the first project (if you have not made up your base mix yet, go here first). By only slightly modifying the base mix, with the addition of one or two chemicals, you can now make two fountains with very different effects: charcoal fountains and ferro-titanium fountains.

Charcoal and Ferro-Titanium Fountains

(click image to play video)

Fountains, technically known as gerbs (sounds like the first syllable in the word 'gerbil'), make nice stand-alone effects. They also create a nice display when used as the "drivers" on fireworks wheels. You can tackle those wheels in the next project.

Instructions for Making Fountains

Mixing Fountain Fuel

Starting with black-powder base mix, you'll be adding either 80-mesh charcoal or 60-100-mesh ferro-titanium to make the two types of fountain fuel. The following formulas and amounts will make enough fuel to construct 5 charcoal fountains and 5 ferro-titanium fountains, using 3/8-inch ID x 3.5-inch long paper tubes.

If you wish to make 10 of one type, though, and none of the other, simply make twice the amount of the fuel for the type you want to make.

Charcoal Fountain Formula (enough for 5 fountains)

Chemical	Percentage	1.3 ounces	37 grams
Black powder base mix	0.85	1.1 ounces	31.5 grams
80-mesh charcoal	0.15	0.2 ounces	5.5 grams
Total	1.00	1.3 ounces	37 grams

Ferro-Titanium Fountain Formula (enough for 5 fountains)

Chemical	Percentage	2 ounces	57 grams
Black powder base mix	0.70	1.4 ounces	39.9 grams
Ferro-Titanium, 60-100 mesh	0.30	0.6 ounces	17.1 grams
Total	1.00	2 ounces	57 grams

For a batch of one of the fuels, weigh each chemical into its own paper cup. Then combine them into one cup and reweigh it to make sure the total weight is what it is shown above. This verifies no mistakes were made during the weighing.

After you have confirmed the correct weight, pour the chemical mixture from the cup into a mixing tub. Install the lid tightly on the tub, and holding the lid on tight, shake the tub to thoroughly mix the fuel.

Using a Sharpie marker, label the fuel in that tub and keep the fuel in the tub during fountain construction, opening it only to remove each necessary increment of fuel.

Weighing and Mixing Fountain Fuel

(click image to play video)

Ramming a Clay Nozzle in a Paper Tube

Now that the fuel is mixed, it's time to start constructing a fountain. The first step in this process is ramming a clay nozzle. For this, you'll need to assemble your materials: clay, fountain tooling, mallet, ramming post, ¼-teaspoon measuring spoon, paper tube, and awl.

Note: Nozzle clay is rammed dry. It will tightly pack into a solid mass during the next steps. Never dampen this clay.

If you are using the combo-tool, place the tube on the shortest spindle on the base. Fountain spindles are typically designed to channel the fountain spray through a nozzle (for greater height), and to be only deep enough to start a thorough burn of the fuel.

Install the ram-through funnel on the top of the paper tube. Scoop out a slightly rounded ¼-teaspoonful of the clay, and dump it into the tube through the funnel.

Insert the hollow ram-drift and slide it up and down in the tube a few times to completely settle the clay to the bottom of the tube. Gently ram (hammer) the hollow drift 6-8 times with the mallet until the clay nozzle feels completely solid.

If you ram the nozzle too hard, you will split the paper tube. If this happens, throw that tube away and start over. A good rule of thumb is to ram the nozzle hard enough to make it very slightly bulge the outside of the tube. You can feel this with your fingers.

Leave the tube and clay nozzle on the tooling. Do not remove it.

Pull the drift out of the tube. Clean any clay out of the hole in the drift with an awl.

Holding the spindle base and tube in one hand, tip them over and gently tap any loose clay out of the tube back into the container of clay.

Now you should have a nice, solid nozzle in the tube. If you'd like to inspect the nozzle and see what it's like, you can gently twist it off the spindle. It's not necessary to remove the tube at this point, though.

Ramming a Clay Nozzle

(click image to play video)

Ramming the Fountain Fuel

If you've removed the tube from the spindle to inspect the nozzle, gently twist it back onto the tooling. You don't want to break the nozzle. Make sure the tube is all the way down onto the base and perpendicular.

Before you begin ramming the fuel, you will need to mark your solid rammer. You have to do this, so you will know when to switch from the hollow ram to the solid one.

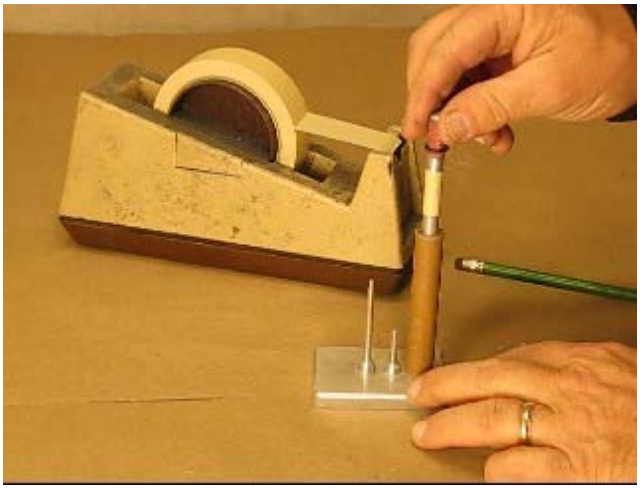
Insert the solid ram-drift all the way into the paper tube until it contacts the spindle. Put a little pencil mark on the drift right at the top of the paper tube. Then pull the drift out of the tube and put another pencil mark on the drift about ¼ inch below the first one. This second mark is the no-pass point beyond which the solid spindle is never rammed into the tube.

Why make the second mark below the first one? Why not just change from hollow to solid rammer right at the top of the spindle?

The second mark allows you to use the hollow drift to ram fuel to ¼-inch above the top of the spindle. You do this to avoid "pinching" the fuel directly between the solid rammer and the top of the spindle. Pinching, the rapid and high compression of pyrotechnic composition directly between two metal parts, can cause fuel to accidentally ignite. That extra ¼ inch of fuel creates a safety buffer to prevent pinching the fuel.

Remove the drift from the tube. Wrap a piece of masking tape around the drift with the bottom edge of the tape where you made your second/bottom pencil mark.

The bottom edge of the tape is the "no-pass" line on the solid drift. Never ram your drift further into the tube than the edge of that tape. This will prevent the drift from ever contacting the spindle.



Marking a No-Pass Line on the Solid Drift

(click image to play video)

Now, start with your hollow drift.

Using the hollow drift, ram a ¼-teaspoonful increment of the fountain fuel in the tube in the same way you rammed the nozzle clay.

Switch to the solid drift. Ram the remaining fuel increments, one at a time with the solid drift, making sure that the drift never goes into the tube deeper than the no-pass line. This is very important.

When you ram the first increment of fuel using the solid drift, the loose fuel should hold the drift up above the no-pass line about ¼ to 3/8-inch. As you ram that fuel, you will be moving the no-pass tape line move down toward the top of the tube; but the tape should never go into the top of the tube. If the tape starts to get close to the top of the paper tube, remove the drift and add more fuel into the tube before you do any further ramming.

Ram more ¼-teaspoon fuel increments until there is only a 3/8-inch empty space remaining in the top end of the paper tube.

Place the excess fuel back into the plastic container and cap it tightly. Remember to always minimize the amount of exposed fuel.

Ramming Fuel in a Fountain

(click image to play video)

Ramming a Clay Bulkhead

When making a fountain, your last ramming step is the clay bulkhead on top.

Remove the ram-through funnel, and empty out any loose fuel in the space at the top of the tube.

Plunge the top of the tube into the loose, dry clay several times to tightly pack it full of the clay.

Then use the solid drift and your mallet to ram the clay into a solid bulkhead.

Ramming a Clay Bulkhead

(click image to play video)

Installing a Fuse and a Stick on a Fountain

Cut a 3-inch piece of Visco ignition fuse.

Wrap a 4-inch long piece of 1-inch wide masking tape around the nozzle end of the fountain. Allow ¾-inch of tape to overhang the end of the paper tube.

Insert the Visco fuse all the way into the nozzle hole until the end of the fuse is pressed against the exposed fountain fuel.

Then tightly close the masking-tape “nosing” around the fuse to hold it in place.

Here’s a tip to make your fountain fast, easy and safe to set up when you’re ready to use it: tape one half of a bamboo skewer onto the side of the fountain with two bands of masking tape, with the fuse up, as shown below.

Installing Visco Fuse and Stick on a Fountain

(click image to play video)

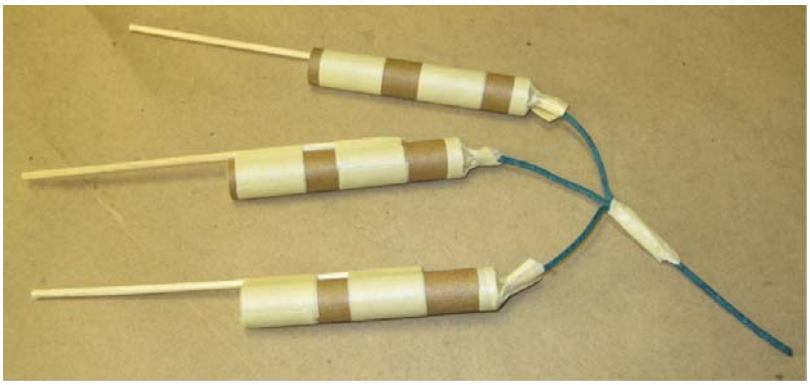
The fountain can now either be stuck in the ground, or in a hole drilled in a block of wood if it is to be fired on a concrete surface. To fire the fountain without a stick taped to it, you could hot-glue it to a base made from a block of wood.

And now, it's ready for show time. Light the fuse and retire to a safe distance. (Fountains can explode for various reasons. So until you know you have yours dialed in, it's best to stay back.)

How to Make a Fountain Fan Display

You can make a “fan” of three fountains by installing longer, 4-inch pieces of Visco fuse in each fountain, and then connecting the three fuses to one ignition fuse with masking tape.

It is important that you cut all three fuses exactly the same length to ensure their simultaneous ignition. Use masking tape to connect the tops of all three fuses as shown below—be sure the fuses are all taped side by side, touching each other (do not try to connect them so they are intersecting--many won’t light this way). Be sure and add the piece of ignition fuse as shown.



Three Fountains Connected with Visco Fuse

Now take the three fountains and set them up in the ground in a fan-shape.

Three- Fountain “Fan” Display

When the single Visco ignition fuse burns down to the point where all the fuses are joined by the masking tape, the three individual fountain fuses will all light at

the same time. Since they are the same length, the three fountains should start at the same time, too. And this is what you should see:

Fan of Three Ferro-Titanium Fountains

(click image to play video)

Chapter 10: How to Make a Fireworks Wheel (Make 2 Wheels)

The Goal

In this project you'll make a wheel, which performs like this.

Fireworks Wheel with Charcoal & Ferro-Titanium Drivers

(click image to play video)

The pyrotechnic devices, which spin the wheel around, are called "drivers." They are mounted onto the frame and fused together to complete the wheel assembly. Wheels can be as small and simple as the one shown below. Or they can be many feet in diameter and vastly more complex, limited only by the laws of physics and your imagination.

This chapter describes how to actually assemble the pyrotechnic drivers onto a wheel frame, and fuse them together for the display.

Frame for Fireworks Wheel

Chapter 2 of Turbo Pyro shows how to make a simple, cardboard fireworks-wheel frame. Two advanced wheel frame options were also described.

If you have not made at least one of those wheel frames yet, do so now. It does not matter which type, but the cardboard circle frame is used in this chapter for illustration. It is best to stick to the wheel frame sizes shown. Their size is matched to the power of the drivers you will be making in this project.

Cardboard Wheel Frame Mounted on Wood Support

Making Fireworks Drivers for a Wheel

The same kind of fountains you made in Chapter 9 will be used as the drivers on this wheel. Learning the Chapter 9 construction technique is a prerequisite for tackling this wheel project. Use the instructions there to see exactly how to make each driver.

This project also utilizes the black-powder base mix you made in Chapter 7. If you have not made up your base mix yet, do so now before proceeding in this project.

Mix the following two batches of fountain/driver fuel:

Charcoal Formula (enough for 6 drivers)

Chemical	Percentage	1.6 ounces	45 grams
Black powder base mix	0.85	1.35 ounces	38.3 grams
80-mesh charcoal	0.15	0.25 ounces	6.7 grams
Total	1.00	1.6 ounces	45 grams

Ferro-Titanium Formula (enough for 6 drivers)

Chemical	Percentage	2.4 ounces	68 grams
Black powder base mix	0.70	1.7 ounces	47.5 grams
Ferro-Titanium 60-100 mesh	0.30	0.7 ounces	20.5 grams
Total	1.00	2.4 ounces	68 grams

Make 4 of the charcoal drivers and mark each of them “C.”

Make 4 of the ferro-titanium drivers and mark them “FT.”

Mix the remaining amounts of the two fuels together. Using this combined fuel, make 4 of the 50/50 drivers and mark them “50/50.”

Two of each kind of the drivers will be used on a wheel, so you should now have enough drivers for two wheels.

Each Fireworks Wheel Uses Three Pairs of Drivers

After you’ve burned one wheel, you can reload the frame and have a second one. Or you can make two frames and have two wheels display simultaneously.

If you plan to make and display two wheels at the same time, it looks really great to have one rotating clockwise, and one counterclockwise. To achieve this, the drivers are mounted on the second wheel in precisely the reverse direction and order of the one, which is about to be described.

These wheels are designed so that each wheel will start with two of the charcoal drivers burning and creating a soft charcoal effect. Then the two 50/50 drivers will ignite and a medium-brightness spark effect will be created. Finally the last two drivers will ignite with an even more brilliant ferro-titanium effect.

Drill Bulkhead Passfire Holes

The charcoal drivers will burn first. When they have spent all their fuel they will pass fire through their bulkheads to ignite fuses, which will burn and ignite the 50/50 drivers.

Then, the 50/50 drivers will burn and pass fire through their bulkheads to the ferro-titanium drivers.

In order to accomplish the passing of fire through the bulkheads, holes must be hand-twist drilled in them.

Using a 1/8-inch drill bit, center the bit in the face of the clay bulkhead. Gently twist the bit by hand, drilling into the clay and keeping the bit perpendicular to the bulkhead face.

Keep drilling until the bit just penetrates the fuel grain by about 1/16-inch.

Be sure to dump the loose clay out of the hole so it doesn't obstruct the fuel when the fuses are installed.

Make passfire holes for the two charcoal drivers and the two 50/50 drivers.

Note: Once you get through the bulkhead clay, you are drilling into a pyrotechnic composition. This must be done slowly with a drill bit twisted by hand. Do not use a power drill to drill passfire holes.

There are bits of ferro-titanium in the 50/50 fuel. So with this fuel especially, if the drilling is done fast there is the chance of sparking and ignition. Make sure no open batches of fuel are in the vicinity when you start drilling. It is safest to do this drilling outdoors.

Hand Twist-Drilling 1/8-Inch Bulkhead Passfire Hole

(click image to play video)

Enlarging Nozzle Holes

The nozzles of all six of the wheel drivers will have yellow fast-Visco fuse inserted into them. That fuse is 1/8-inch in diameter.

To ensure that the fuse will fit into the nozzles, check to see if you need to open up the existing nozzle holes a little. Hand twist-drill the driver nozzle holes with a 1/8-inch drill bit until the bit just hits the fuel grain. Do this gently, the same way the bulkhead holes were drilled.

Installing Masking-Tape "Nosings" on Drivers

Nosings need to be installed on the nozzle ends of all drivers and on the ends of any drivers with bulkheads that have been drilled. These tape nosings will hold the fuses in place in the nozzle and bulkhead holes.

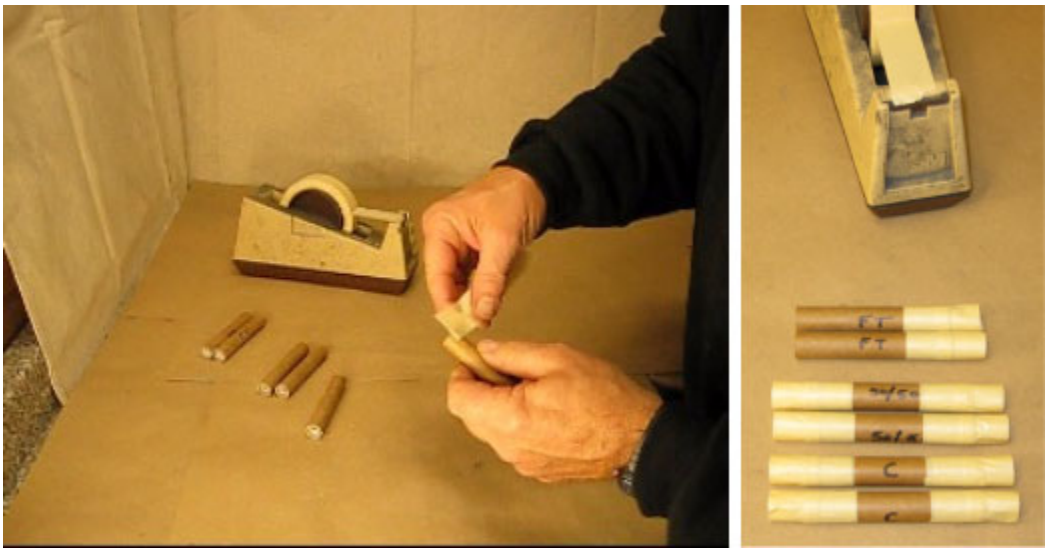
With your fingers, clean all clay dust off the outside and ends of all the tubes.

Tear off a 4.5-inch long piece of one-inch wide masking tape, and install the tape on the driver end. Apply about ¼-inch of the tape onto the outside of the tube itself and leave ¾-inch to hang over the end of the tube. The tape should be long enough to make two turns around the tube.

Then put another band of tape around the tube, overlapping the ¼-inch of tape on the tube, to really secure the nosing in place. The fuse and nosings have to withstand strong centrifugal force when the wheel is spinning. If the connections come loose, your wheel will come apart, stop, or not perform correctly.

Put these tape nosings on all the driver tube ends except the undrilled bulkhead ends on the ferro-titanium drivers. They are the last ones to burn and will not be passing fire to anything else on the wheel.

When all the tape nosings are in place, you can tell the nozzle ends of the drivers from the passfire ends by simply looking through the nosings at the ends. The nozzle ends look quite different than the bulkhead ends.



Installing Masking-Tape Nosings on Wheel Drivers

(click image to play video)

Mark Driver Locations on Wheel Frame

There will be six drivers around the perimeter of the wheel frame. So the outside of the frame needs to be marked with those six driver locations.

Measure the circumference of the wheel frame with a cloth-sewing tape measure.

Divide that circumference length by 6 to determine where each of the 6 drivers will be placed.

Put a “starter” mark on the edge of the wheel frame. Silver Sharpie markers work well to mark black surfaces.

Measure around the edge of the frame by 1/6 of the circumference, and make another mark.

Repeat this until you are back where you started. You now have 6 marks, which should all be equidistant from each other, around the edge of the frame.

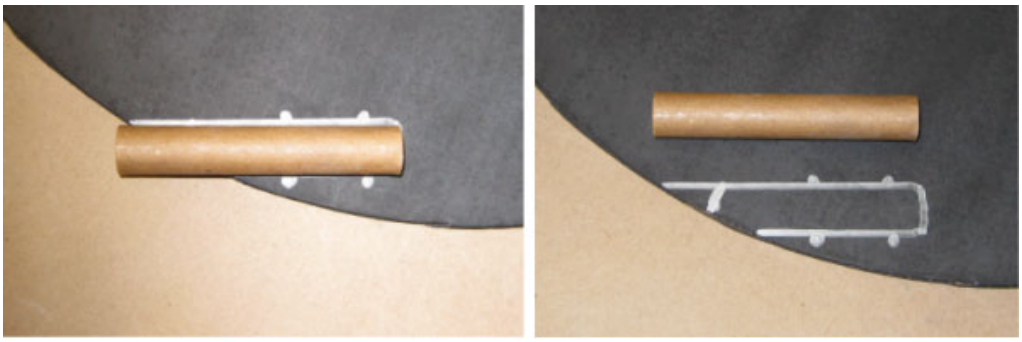
Measuring and Marking Frame for Driver Locations

(click image to play video)

Marking Driver Attachment Points

Mounting the drivers on a slight angle to the edge of the frame will ensure they don’t burn the frame as they spew forth their magical sparks. The correct angle points the driver directly at the next driver location mark to the right.

Mark the driver location and attachment points at each of the 6 driver locations on the frame as shown below. The “dots” are where you will be punching holes through the frame.



Marking Driver Attachment Points on Wheel Frame

(click image to play video)

Attaching the Drivers to the Wheel Frame

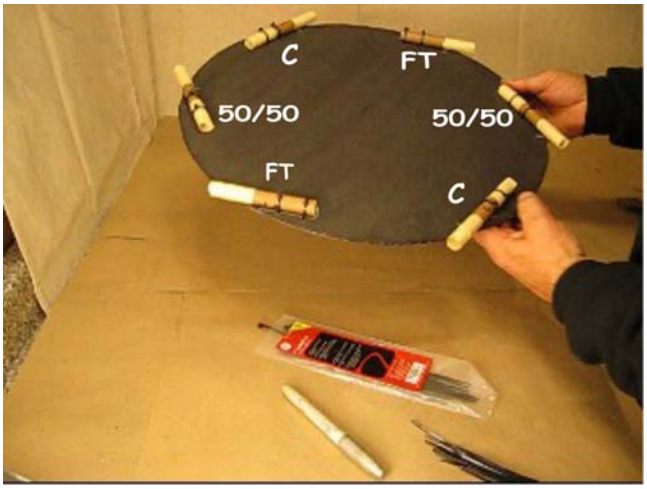
This wheel will rotate counter-clockwise, so the drivers are attached with the nozzle end to the left (outside the wheel). They will then turn the wheel in the desired direction.

Pierce each attachment point with an awl.

Make sure you attach each driver tightly, with the nozzle end pointing left (outside the wheel), with two 8-inch cable ties. Clip off the excess tie plastic end.

First, attach a charcoal driver, then a 50/50 one at the next attachment point to the right of the first one, and then a ferro-titanium driver to the right of that one. Repeat that process with the next three attachment points. So, your 6 drivers should end up attached in this sequence, going counterclockwise.

- Driver 1: Charcoal
- Driver 2: 50/50
- Driver 3: Ferro-titanium
- Driver 4: Charcoal
- Driver 5: 50/50
- Driver 6: Ferro-titanium



Attaching Drivers to Wheel Frame

(click image to play video)

Fusing the Wheel

Yellow fast-Visco fuse is used to attach the drivers to each other so they ignite in sequence.

Using a razor blade or razor-anvil cutters put a nice fresh cut on one end of a length of the fast-Visco fuse. Insert that end all the way into the nozzle end of one of the ferro-titanium drivers.

Crimp the driver's nosing around the fuse, and tie the nosing tape securely around the fuse with a piece of string.

Now pay careful attention to the next instructions.

Fusing will be done to your left.

From your first fused driver, stretch the fuse over to the passfire end of the next (50/50) driver to the left. Then cut the fuse so that it will be long enough to penetrate all the way to the bottom of the bulkhead passfire hole in the 50/50 driver. Insert the end of the fuse into the bulkhead hole and make sure it bottoms out against the fuel. Then crimp and tie the nosing around the fuse.

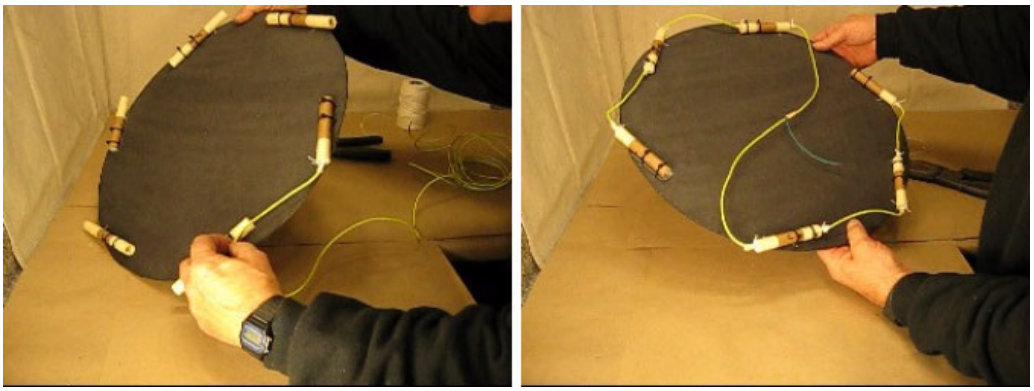
Make sure your fuses are long enough to do the job, but no longer than necessary.

Repeat this fusing process between the nozzle end of the 50/50 driver and the passfire end of the charcoal driver to its left. Do not put a fuse into the nozzle end of the 3rd (charcoal) driver yet. Leave it empty for now.

Using two more pieces of fast yellow Visco, connect the other 3 drivers on the opposite side of the wheel in the same way, starting with the other ferro-titanium driver.

Now, connect the nozzle ends of the two charcoal drivers with a longer piece of the fast-Visco fuse. See the photo on the right below.

Tape a piece of green Visco ignition fuse right in the middle of that long piece of fast-yellow Visco, which connects the charcoal drivers.



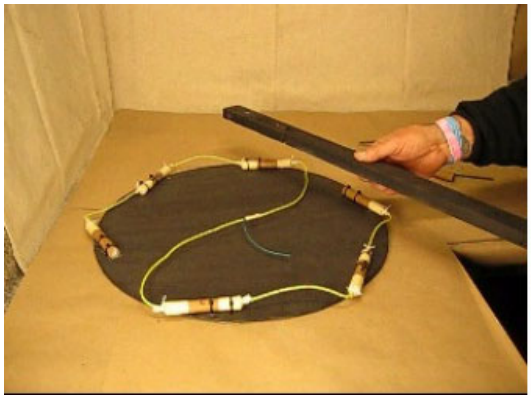
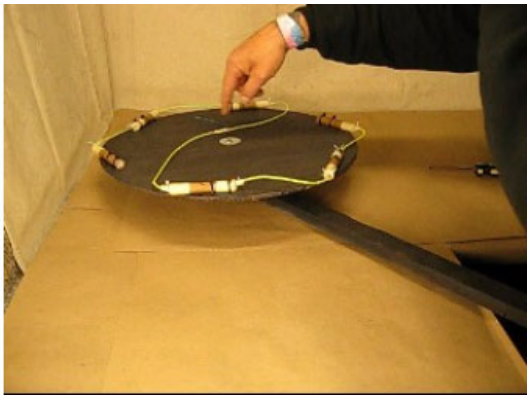
Connecting the Wheel Drivers with Fuse

(click image to play video)

Attaching Wheel Frame to Wood Support

Any 8-foot long piece of lumber will work as a support for this wheel.

As described in Chapter x on making the wheel frame, re-attach the wheel to the wood support.

Attaching Wheel to Wood Support

(click image to play video)

Drive a fence post or other stake into the ground, and use tape to securely attach the wheel support to the stake.

Bend the green ignition-Visco fuse downward for easy lighting when it comes time to fire your wheel.

After the display, remove the wheel frame and store it in a dry location for re-use in the future. Dew or rain will damage the cardboard frame if you leave it sitting out.

Chapter 11: Magnum Bottle Rockets (Make 10 Rockets)

In this project you'll make magnum bottle rockets, which are "big brothers" of the ones you can buy at the corner fireworks store.

Charcoal-Tailed Magnum Bottle Rockets in Action

(click image to play video)

Instructions for Making a Magnum Bottle Rocket

Before you begin:

This project utilizes the black-powder base mix described in Chapter 7 (if you have not made up your base mix yet, go here first).

You will also be using 3/8" pumped stars described in Chapter 6. If you have not made those yet, go here and do so now.

These rockets will be made using 3/8-inch ID, 3.5-inch-long paper tubes, with 12-inch-long bamboo skewers for their sticks.

So, while they are similar in scale to a consumer fireworks bottle rocket, the motor is larger, and the display more impressive.

But, they are still small and quiet enough to be launched anywhere a standard bottle rocket would be safe to fly. You will be making a nice, backyard-scale rocket in this project.

Mixing the Rocket Fuel

The these rockets is made by adding some 80-mesh charcoal to the dried black-powder base mix fuel for

Rocket Fuel Formula (enough for 10 rockets)

Chemical	Percentage	2 ounces	57 grams
Black-powder base mix	0.80	1.6 ounces	45.6 grams
80-mesh charcoal	0.20	0.4 ounce	11.4 grams
Total	1.00	2 ounces	57 grams

To make a batch of rocket fuel, weigh each component into its own paper cup. Then combine both components into one cup and reweigh it to make sure the total weight is what it is shown above. This verifies no mistakes were made during the weighing.

After you have confirmed the correct weight, pour the chemical mixture from the cup into a mixing tub. Install the lid tightly on the tub, and holding the lid on tight, shake the tub to thoroughly mix the fuel.

Using a Sharpie marker, label the fuel in that tub and keep the fuel in the tub during rocket construction and open it only to remove each necessary increment of fuel.

Ramming a Clay Nozzle in a Paper Tube

The first step in actual rocket construction is ramming a clay nozzle in the motor tube. Assemble your materials: clay, rocket tooling, mallet, ramming post, ¼-teaspoon measuring spoon, paper tube, and an awl.

Note: Clay is rammed dry. It will tightly pack into a solid mass during the ramming. Never dampen this clay.

If you are using the combo-tool, place the tube on the longest spindle on the tooling base. The long spindle will create a hole through the clay rocket nozzle, and a core up into the rocket fuel grain. The large fuel surface area created in this core will ignite instantaneously and produce large amounts of gas quickly, which will propel the rocket into the air.

Install the ram-through funnel on the top of the paper tube. Scoop out a slightly rounded ¼-teaspoonful of the clay and dump it into the tube through the funnel.

Insert the hollow ram-drift, and slide it up and down in the tube a few times to completely settle the clay to the bottom of the tube. With the spindle base on the

ramming post, gently ram (hammer) the hollow drift 6-8 times with the mallet until the clay nozzle feels completely solid.

Remove the drift from the tube and clean any clay out of the hole in the drift with an awl.

Holding the spindle base and tube in one hand, tip them over and gently tap any loose clay out of the tube back into the container of clay.

There is now a nice, solid nozzle formed in the rocket tube.

Ramming the Rocket Fuel

Before you begin ramming any fuel, you will need to mark your hollow and solid rammers. You have to do this, so you will know when to switch from the hollow ram to the solid one. It prevents you from ever hitting the spindle with your solid drift when you are ramming fuel.

Remove any masking tape that may have been left on the solid drift from previous projects.

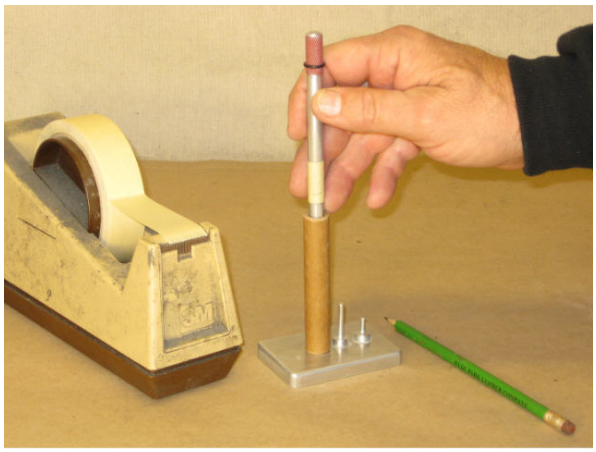
Insert the solid ramming drift all the way into the paper tube until it contacts the tip of the spindle. Put a little pencil mark on the drift right at the top of the paper tube. Then pull the drift out of the tube and put another pencil mark on the drift about ¼-inch below the first one. This second mark is the “no-pass” point beyond which the solid spindle is never rammed into the tube.

Why make the second mark below the first one? Why not just change from hollow to solid rammer right at the top of the spindle?

The second mark allows you to use the hollow drift to ram fuel to a point ¼-inch above the top of the spindle. You do this to avoid “pinching” the fuel directly between the solid rammer and the top of the spindle.

Pinching, the rapid and high compression of pyrotechnic composition directly between two metal parts, can cause fuel to accidentally ignite. That extra ¼ inch of fuel creates a safety buffer to prevent pinching the fuel.

Remove the drift from the tube. Wrap a piece of masking tape around the drift with the bottom edge of the tape where you made the second/bottom pencil mark.



Marking No-Pass Line on Solid Drift with Masking Tape

(click image to play video)

Now put a mark ¼-inch up on the solid drift's no-pass masking tape. This is where the top of the tube would be if the drift was inserted all the way until it hit the spindle.

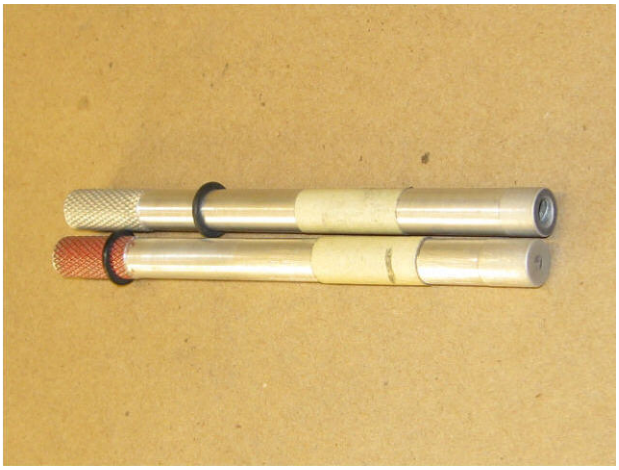
Warning: Never ram your drift further into the tube than the "no-pass" edge of the tape. This will prevent the drift from ever contacting the spindle and prevent accidental ignition of the rocket.

Align the bottoms of the solid and hollow drifts and put a mark on the hollow drift alongside the mark you just made on the solid drift's tape. Wrap a single layer of tape around the hollow drift with the bottom of the tape aligned with the mark on it.

The bottom of the tape on the hollow drift marks how far that drift is inserted into the tube when the end of the drift is even with the top of the spindle.

When fuel is being rammed in the tube, the hollow drift must be used until that edge of the tape is at or above the top of the tube. That indicates that fuel has been rammed to, or slightly above, the top of the spindle. Then you can switch to the solid drift to ram the remaining fuel and the clay bulkhead.

Note: If your hollow drift will not slide into the paper tube with this piece of tape on it, use the black Sharpie marker to make a mark where the bottom of the tape is and remove the tape. Keep an eye on the Sharpie mark as you are using the hollow drift, and refresh the mark as it gets worn off.



Marking Hollow Drift with Masking Tape

Load ¼-teaspoonful of the fuel into the paper tube through the ram-through funnel. Using the hollow rammer, consolidate the fuel with 6-8 whacks with the mallet.

Repeat this with increments of the fuel until the mark on the hollow drift is even with, or slightly above, the top of the tube after an increment is rammed.

Switch to the solid rammer and ram two increments of fuel, making sure the no-pass line never goes into the paper tube. This should bring the no-pass line to about ¼ inch above the edge of the tube after the final fuel increment.

Since the no-pass line would be in the tube ¼ inch if the solid drift was in contact with the tip of the spindle, when that line is ¼ inch above the tube's edge after ramming a fuel increment, there should be ½ inch of fuel rammed above the spindle.

That amount of fuel above the spindle will create a "delay" time as the rocket flies upward before the "heading" is ignited.

The fuel above the spindle burns more slowly than the fuel below it did, and creates a coasting, "delay" portion of the flight.

Once that delay fuel has burned, the "heading" is ignited. The heading, if you have installed one, is the effect attached to the top of the rocket motor, designed to create a visual and/or audible fireworks effect at the end of the rocket's flight.

Place the excess fuel back into the plastic container and cap it tightly. Remember to always minimize the amount of exposed fuel.

Ramming a Clay Bulkhead

After the fuel has been rammed to ½-inch above the tip of the spindle, as described above, ram a ¼-teaspoon increment of clay to form a bulkhead in the top of the rocket motor.

Drill a Passfire Hole through the Bulkhead

After the delay fuel has burned up, in order for the rocket motor to pass fire to the heading, a hole must be drilled through the clay bulkhead.

Using a 1/8-inch drill bit, center the bit in the face of the clay bulkhead and gently twist the bit by hand, drilling into the clay and keeping the bit perpendicular to the bulkhead face.

Drill all the way through the clay bulkhead and just penetrate the fuel grain about 1/16-inch.

Dump all the loose clay out of the passfire hole so it doesn't obstruct the fuel.

Warning: You are drilling directly into a pyrotechnic composition once you get through the bulkhead clay. You must do this slowly with a drill bit twisted by hand. Do not use a power drill to do this. Make sure no open batches of fuel are in the vicinity when this operation is undertaken. It is best to do this drilling outdoors.

Ramming Fuel in a Magnum Bottle Rocket Motor

(click image to play video)

Adding a Heading to the Rocket Motor

Various types of headings can be added to one of these rocket motors to create some fireworks effect at the top of its flight.

Of course, you may want to omit the heading completely for your first test flights. In that case do not drill the bulkhead passfire hole.

If you do want to add a heading to your rocket, you could use some 3/4-inch pieces of flying-fish-fuse. Or you could use some loose powder, such as the same black-powder rocket fuel you used to make the motor. A pinch of ferro-titanium in that loose rocket fuel would produce a spray of sparks to accompany the heading's "pop" at the end of its upward flight.

But this project will show you how to use 3/8-inch pumped stars in the heading.

The first step in adding a heading to the rocket motor is to cut a ½-inch piece of yellow, fast Visco fuse and insert it all the way into the bulkhead hole until the fuse bottoms out against the fuel.

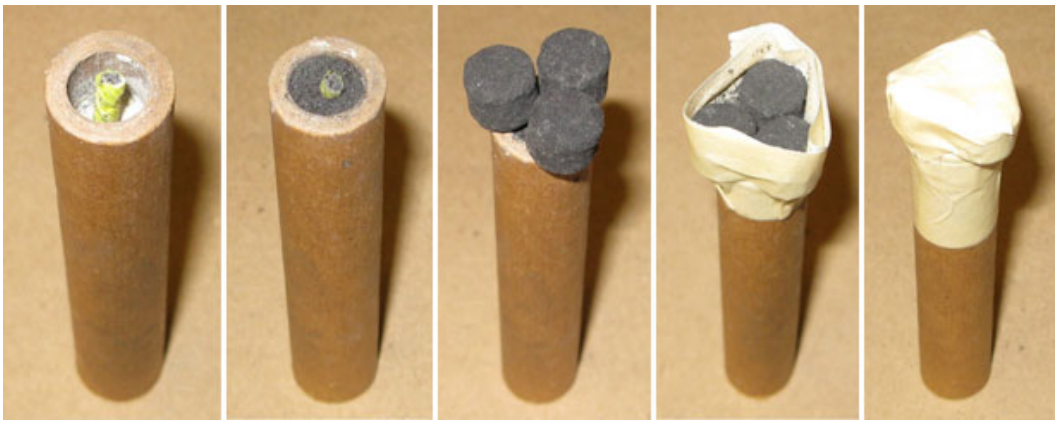
Then install the ram-through funnel and fill the void in the end of the motor tube, around the fast Visco fuse, all the way to the top with loose rocket fuel as shown in the photo sequence below. Remove the funnel.

Then, balance one, three, or more stars on the end of the tube, and wrap the stars with two turns of masking tape.

Seal the masking tape against the motor tube tightly. Then put two more tight turns of tape around the tape on the motor tube to firmly attach the wrap to the tube.

Loosely fold the masking-tape wrap over the top of the stars. Put one small piece of tape over that end to hold the stars in place.

The idea is to have the stars ejected out of the end of the heading tape enclosure after they are ignited by the burning, loose rocket fuel.



Installing a Rocket Heading of 3/8-Inch Pumped Stars

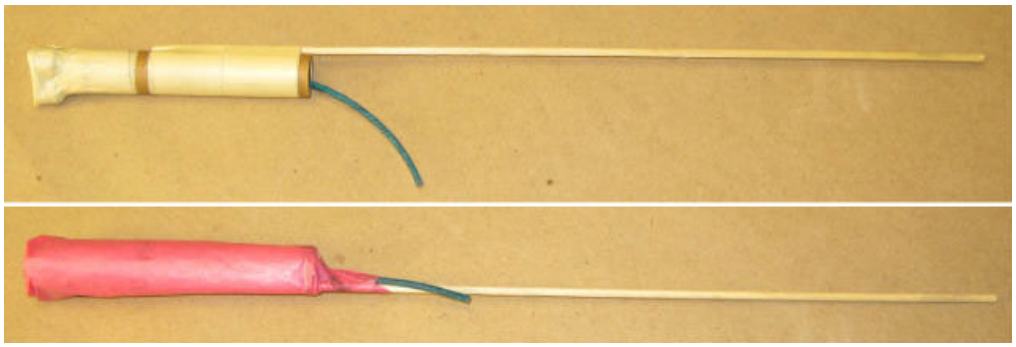
(click image to play video)

Finishing the Rocket

To finish the rocket, use two 5-inch long bands of masking tape to attach a 12-inch bamboo skewer to the side of the motor. Lap the stick up onto the side of the motor about 2.5-inches. Keep the stick straight in alignment with the motor as you attach it.

Insert a 4-inch long piece of Visco ignition fuse into the hollow core of the motor, pushing the fuse in as far as it will go.

If you wish to, a 3-inch by 5-inch piece of colored tissue or gift-wrapping paper can be glued around the motor to give it a finished look.



Finishing a Rocket with a Stick, Fuse, and Decorative Wrapping

(click image to play video)

The Finished Product

It's hard to find tall, glass pop-bottles anymore, which were ideal for launching bottle rockets. But, any piece of pipe, a foot or two long, will serve as a launching tube for these magnum bottle rockets.

Anchor the tube solidly into the ground or into a hole drilled into a block of wood to serve as a base.

Insert the bottle rocket with the Visco fuse hanging outside the top of the tube, light the fuse and retire to a safe distance to enjoy the rocket's flight.

Magnum Bottle Rocket Launching from a PVC Pipe

(click image to play video)

Chapter 12: How to Make Fireworks Helicopters (Make 10 Helicopters)

Technically known as “tourbillions,” these whirling helicopters are fun little devices. They start their flight by spinning around on a flat launching platform on the ground. Then as they continue to spin, they lift skyward, creating a whirlwind of charcoal sparks. They finish by spitting out bursts of charcoal sparks in opposite directions.

Fireworks Helicopter with Launch

(click image to play video)

Making a Fireworks Helicopter

Before You Begin

This project utilizes the black-powder base mix described in Chapter 7. If you have not made up your base mix yet, you will need to go here first.

You will also need 10 of the 3/8” ID by 3.5” long tubes.

Mixing the Helicopter Fuel

The fuel for these helicopters is made by adding some 80-mesh charcoal to dry black-powder base mix.

Helicopter Fuel Formula (enough for 10 helicopters)

Chemical	Percentage	3 ounces	85 grams
Black-powder base mix	0.95	2.85 ounces	80.8 grams
80-mesh charcoal	0.05	0.15 ounces	4.2 grams
Total	1.00	3 ounces	85 grams

For a batch of helicopter fuel, weigh each component into its own paper cup. Then combine them into one cup and reweigh it to make sure the total weight equals what it is shown above. This verifies no mistakes were made during the weighing.

After you have confirmed the correct weight, pour the chemical mixture from the cup into a mixing tub. Install the lid tightly on the tub, and holding the lid on tight, shake the tub to thoroughly mix the fuel.

Using a Sharpie marker, label the fuel in that tub. Keep the fuel in the tub during helicopter construction, opening it only to remove each necessary increment of fuel.

Note: Now is a good time to plug your hot-glue gun in and get it heated up and ready to go when you need it.

Warning: Hot-glue guns, especially cheap ones, have been known to malfunction and spit sparks out of their sides. It is therefore an excellent idea to plug the gun in at a location that is away from the area where you are working with pyrotechnic materials. And, just before you use the gun on a fireworks device, unplug it and use it while it is still hot but has no electricity flowing through it. Never have a plugged-in hot-glue gun sitting on a workbench near flammable materials.

Ramming a Clay Plug in a Paper Tube

The main body for one of these helicopters is a 3/8-inch ID, 3.5-inch long paper tube.

The first step in the actual helicopter construction is ramming a clay plug in one end of the tube. Assemble your materials: clay, tooling, mallet, ramming post, ¼-teaspoon measuring spoon, masking tape, and a paper tube.

Note: Clay is rammed dry. It will pack tightly into a solid mass during the ramming. Never dampen the clay.

If you are using the Combo Tool, insert the paper tube into the white plastic drill guide until the end of the tube is flush with the far side of the guide. The guide serves as a nice tube support during the ramming operations.

Place a piece of masking tape over the end of the tube and the guide to seal off that end of the tube.

Place the tube and guide on the aluminum ramming base. Install the ram-through funnel on the top of the tube.

Drop a slightly rounded ¼-teaspoonful of the powdered clay through the funnel and into the tube.

Insert the solid rammer. Push it in and out of the tube several times to pack the clay at the bottom of the tube. Tap the rammer 8 times with the mallet until the clay plug feels solid and compacted.

Remove the rammer and funnel and dump any loose clay out of the tube back into the tub of clay. Insert the rammer back into the tube and mark where the top end of the tube is on the rammer. Remove the rammer and hold it alongside the tube to verify that a ¼-inch long clay plug was created in this process. Adjust your clay increment accordingly in the future.

Ramming a Clay Plug in Helicopter Tube

(click image to play video)

Ramming the Helicopter Fuel

Measure two tablespoons of fuel into a paper cup. Put the lid back on the tub tightly to minimize exposure of the fuel during construction.

Put the ram-through funnel on the paper tube, and ram ¼-teaspoon increments of the fuel into the tube the same way you rammed the clay plug.

Preparing to Ram Increments of Fuel into Helicopter Tube

(click image to play video)

Keep ramming one increment at a time until there is only ¼-inch of the tube empty at the top.

Remove the funnel and dump any loose fuel out of the tube back into the paper cup. Put the excess fuel in the cup back into the tub of fuel and close it tightly.

Ramming the Second Clay Plug

With the funnel removed from the paper tube, plunge the open end of the tube into the tub of powdered clay until the end of the tube is completely filled with a bulging increment of clay.

Ramming the Final Clay Plug

(click image to play video)

Ram this clay increment. Refill the void with clay as necessary and ram the clay again to make the clay plug almost flush with the end of the paper tube.

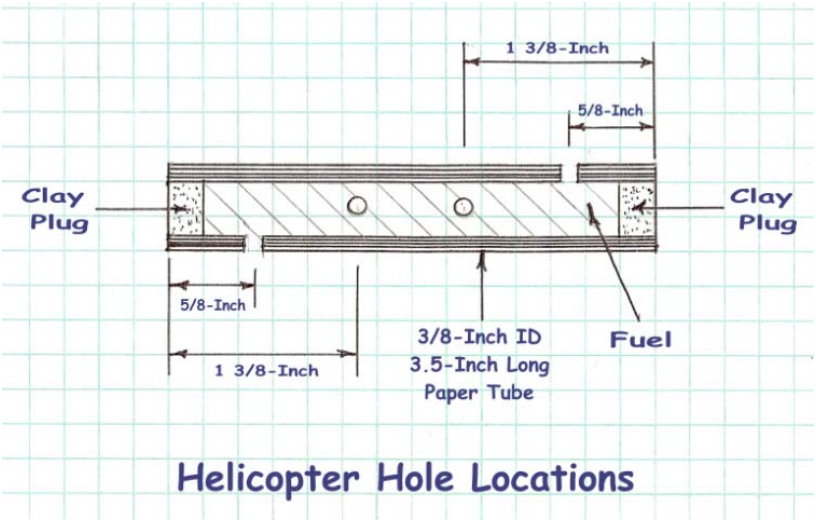
Remove the tube from the plastic drill guide and remove the tape from the bottom of the tube or guide.

Drilling Spin Holes in Helicopter Tube

To make the helicopter start spinning on its launch platform, there will need to be two holes drilled in its sides.

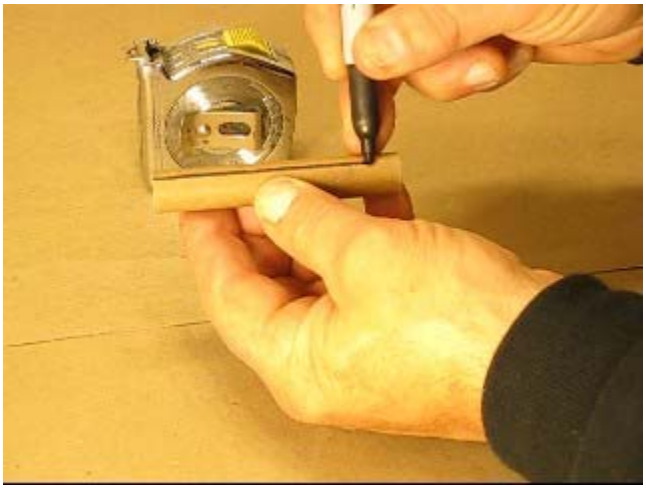
Two additional holes in the helicopter's bottom will then be drilled to lift the helicopter into the air.

The locations of these holes must now be marked on the paper tube.



Locations of 1/8-Inch Holes in Helicopter Tube

Find the edge of the wrapped paper which makes up the tube. This edge runs lengthwise down the tube, and will serve as a good straight starting line for marking the hole locations. Run a pencil or Sharpie marker down this paper edge to create a line running the length of the tube. This line will be on the bottom of the helicopter.



Marking Bottom Line on Helicopter Tube

Now put a mark on the tube's end that aligns with the bottom line.

Put a mark directly opposite of the first mark on that same end. Connect those two marks on the end with a little line as shown below.

Put two marks half way between each of those two marks.

Marking an X on the Helicopter Tube's End

These last two marks show where lines on the sides of the tube, up 90 degrees from the bottom mark on each side of the tube, will line up.

In the same way you marked the bottom line, put marks on the sides of the tube, which line up with these sideline marks.

Marking Side Lines on Helicopter Tube

(click image to play video)

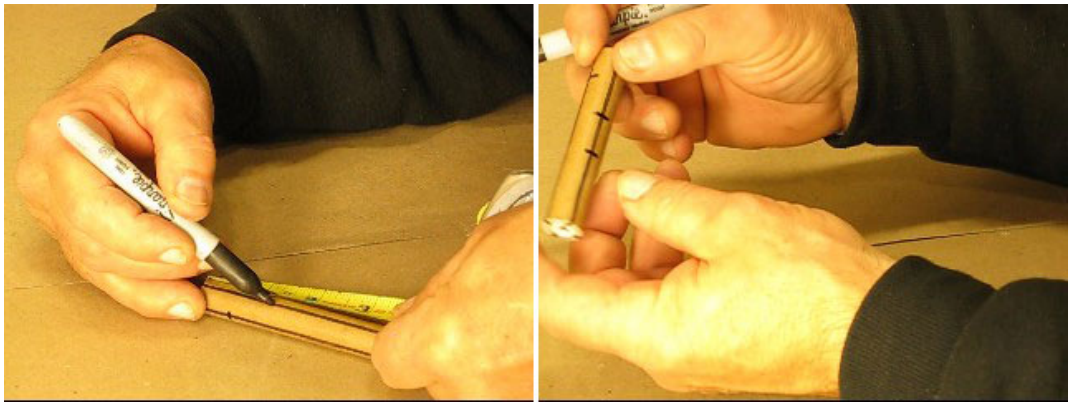
Now make the marks for the locations of the four 1/8-inch holes, which need to be drilled in the helicopter tube.

On one of the side lines, put a mark measured in 5/8-inch from one end.

On the other side line, put a mark measured in 5/8-inch from the other end.

These marks you just made are where the holes will be located that spin the helicopter.

On the bottom line, put marks measured in 1 3/8-inch from each end. The marks on the bottom are where the holes will be located that lift the helicopter.



Measuring and Marking Hole Locations on Helicopter Tube

(click image to play video)

Warning: Perform the following operation:

Wearing eye protection and cotton clothing.

Outdoors.

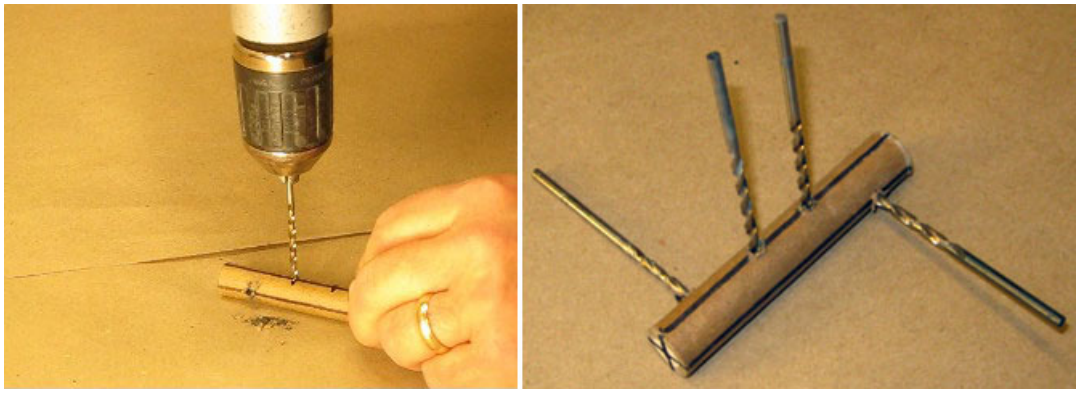
Away from any exposed pyrotechnic compositions.

Slowly.

Carefully.

With a very sharp 1/8-inch drill bit.

Using a sharp 1/8-inch drill bit, and holding the drill perpendicular to the tube's side, drill holes slowly just through the paper tube wall and just into the helicopter fuel–not all the way through it. Drill at all four hole locations, which you marked on the tube.



Drilling Four 1/8-Inch Holes at Marked Locations on Helicopter Tube

(click image to play video)

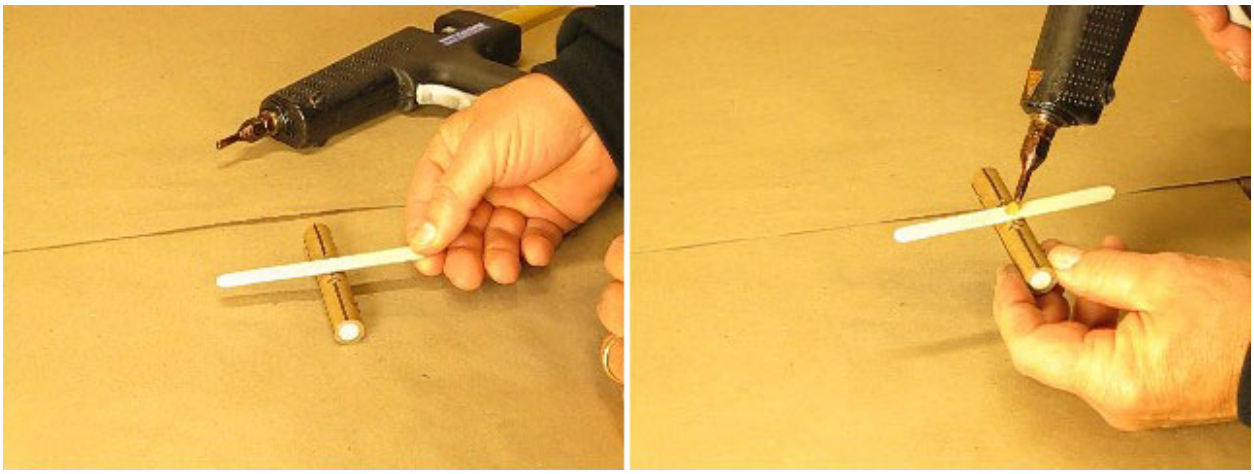
Installing Helicopter Stick

The stick on the helicopter will look like a “wing” or “propeller,” but its only function is to keep the helicopter tube-body positioned with the bottom holes pointing down during spinup on the launching platform and during its flight.

The stick is a standard Popsicle stick, or craft stick, 4.5-inches long and about 3/8-inch wide.

Unplug your hot-glue gun, which is now hot, and put a dab of glue on the bottom of the helicopter tube right in the middle of the tube between the two bottom holes. Press the stick onto the glue with the middle of the stick crossing the middle of the tube.

Put another dot of glue on the outside of the stick right at its middle point. This dot will serve as the pivot point where the helicopter can spin prior to rising skyward.



Hot-Gluing Stick on Helicopter and Pivot Dot on Stick

(click image to play video)

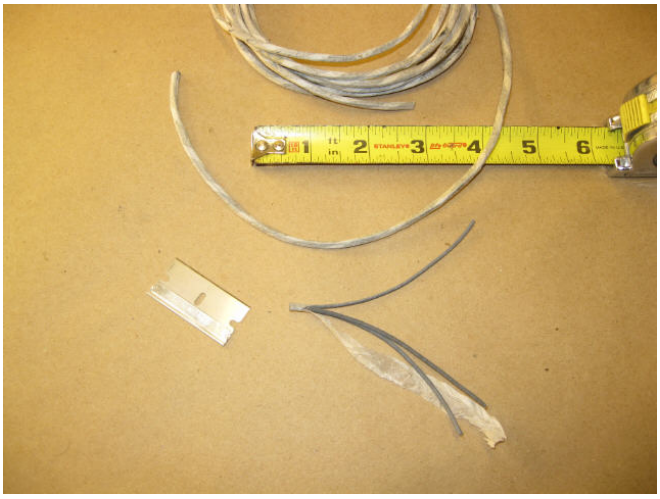
Fusing the Helicopter

The holes in the helicopter tube now get joined together in a particular order with thin blackmatch.

There are three strands of this thin blackmatch fuse in paper-wrapped fast-fuse.

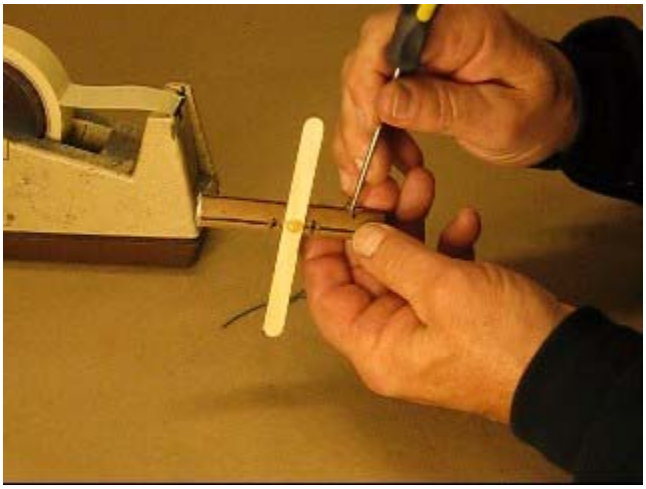
If you are using paper-wrapped fast-fuse, cut a 3.5-inch long piece of it with a razor-blade cutter.

Remove the paper wrapping from the length of fuse to reveal three thin strands of blackmatch.



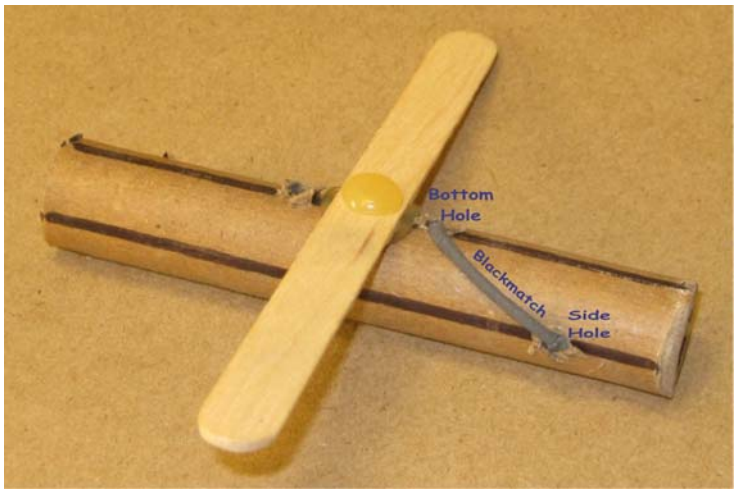
Harvesting Blackmatch

Now clean out the holes in the helicopter tube with an awl. Remove any paper "fuzz" obstructing the holes.



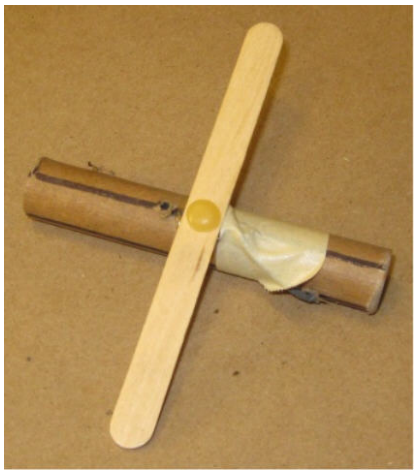
Cleaning out Helicopter Holes with an Awl

Stick the end of a piece of the blackmatch into one of the bottom holes. Wrap the match up and over to the side hole in the tube, nearest to that bottom hole, on that same side of the stick. Cut the match ¼-inch longer than the side hole with a razor blade, and stick that end of the fuse into the side hole. This connects the bottom hole to the side hole on that half of the tube.



Connecting Bottom Hole and Side Hole with Blackmatch

Cover the fuse with a 1-inch by 1 inch piece of masking tape, only sticking the tape securely around the fuse as it goes into the bottom hole, as shown in the photo below. Leave the side hole open.



Putting Masking Tape over Piece of Blackmatch

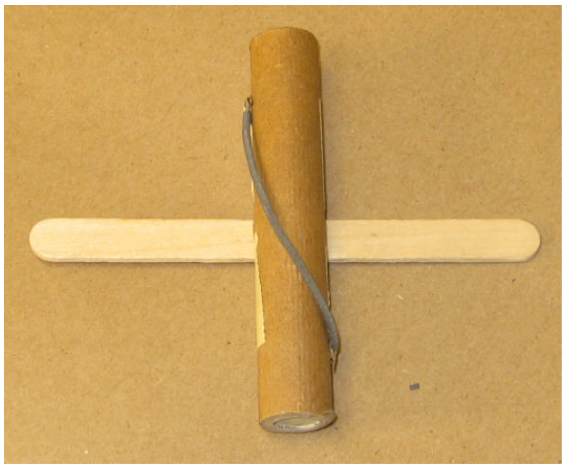
(click image to play video)

Repeat this step on the other side of the tube. Connect the other bottom hole to the other side hole with fuse. Then, apply a piece of tape to cover the fuse; press it tightly over the bottom hole, leaving the side hole open.

Insert one end of another 3.5-inch piece of blackmatch into one of the side holes, alongside the first piece of match already in that hole. If you need to, use the awl to widen the open area in that hole so you can get the match in there.

Bend the fuse over the top of the tube toward the other side hole. Use the loose corner of the masking tape that is already there to tape the fuse where it enters the first side hole.

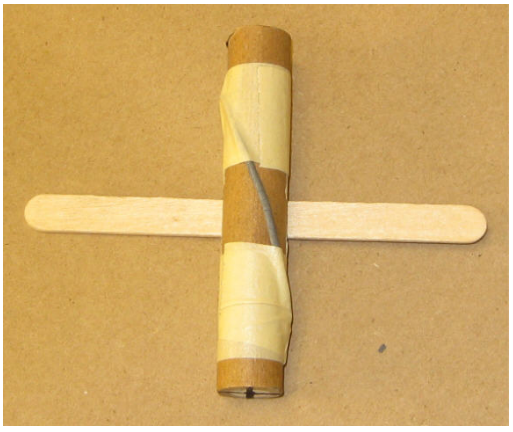
Trim the match ¼-inch past the other side hole using your razor blade. Bend the match and insert it into the side hole alongside the piece of match already there. Use the awl to open the hole up if necessary.



Connecting Side Holes with Blackmatch over the Top of the Tube

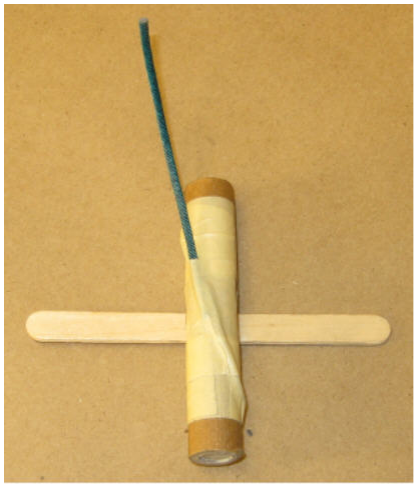
Tear off a 4-inch piece of masking tape and wrap it completely around the tube on one side of the stick, completely covering the two holes and the fuse on that end of the tube. Press the tape firmly around the fuse.

Repeat this on the other part of the tube.



Taping the Tube on Both Sides of the Stick

Now tape a 4-inch piece of Visco ignition fuse dead center on the top of the tube so it contacts the piece of blackmatch there.



Taping Ignition Fuse on Center Top of the Tube

This simple helicopter is now ready to fly. Use a flat, smooth launching platform. A piece of scrap plywood serves that purpose nicely.

When the Visco ignition fuse burns to the top center of the tube, it passes fire to the piece of blackmatch connecting the two side holes.

When blackmatch burns in an enclosed space, as it does when it's covered with the masking tape, it burns almost instantaneously.

The blackmatch will burn from the top center of the tube in both directions toward the side holes, and ignite the helicopter fuel inside those holes.

This will start the helicopter spinning and ignite the other two pieces of blackmatch, which burn quickly down to the bottom holes.

When the fuse ignites the fuel inside the bottom holes, the spinning firework rises into the air.

Inside the tube, the fuel is burning in both directions from each hole. When the fuel burns through between the side and bottom holes, and between the bottom holes, a rapid pressurization occurs inside the tube and an extra-large spray of sparks erupts from all 4 holes, creating a nice final effect.

Helicopter Launching and Flying Skyward

(click image to play video)

Chapter 13: Making Stinger Missiles (Make 10 Stingers)

Stinger missiles are rockets which do not need a stick or fins for stable flight. Instead they spin and are stabilized gyroscopically. They fly skyward, leaving a nice straight tail of charcoal sparks, and also slinging a circle of sparks out sideways. Very cool looking. Stingers are launched off a simple little launch pin in a block of wood.

They are fast, easy, and uncomplicated to make. You can make one and fly it in 5 minutes or less—a lot less time than it takes to read how!

Launch of a Fireworks Stinger Missile

(click image to play video)

Making a Stinger Missile

Before you begin:

This project utilizes the black-powder base mix described in Chapter 7. If you have not made up your base mix yet, go here first and make it.

You will also be using 3/8-inch pumped stars described in Chapter 5. If you have not made those yet, go to Chapter 5 and do so now.

Mixing the Stinger Missile Fuel

The fuel for these missiles is made by adding some 80-mesh charcoal to black-powder base mix (Chapter 7).

Stinger Missile Fuel Formula (enough for 10 missiles)

Chemical	Percentage	1 ounce	30 grams
Black-powder base mix	0.95	0.95 ounces	28.5 grams
80-mesh charcoal	0.05	0.05 ounce	1.5 grams
Total	1.00	1 ounce	30 grams

To make a batch of stinger missile fuel, weigh each component into its own paper cup. Then combine both components into one cup and reweigh it to make sure the total weight is what it is shown above. This verifies no mistakes were made during the weighing.

After you have confirmed the correct weight, pour the chemical mixture from the cup into a mixing tub. Install the lid tightly on the tub, and holding the lid on tight, shake the tub to thoroughly mix the fuel.

Using a Sharpie marker, label the fuel in that tub and keep the fuel in the tub during missile construction. Open it only to remove each necessary increment of fuel.

Cutting Paper Tubes

These stingers use 3/8-inch ID, 1.75-inch-long paper tubes. So, cutting a standard 3-1/2-inch long rocket tube in half will produce two stinger missile tubes. Cut 5 tubes in half, which will yield you 10 completed stinger missiles.

Measure 1.75-inches from one end of a 3/8-inch tube, and mark that point on the tube.

Cut the tube at the mark, using a sharp saw and a miter box to produce nice, square, clean cuts.

Cutting a Paper Tube with Miter Box and Saw

(click image to play video)

Ramming a Clay Nozzle in a Paper Tube

The first step is to ram a clay nozzle in the stinger missile tube. Assemble your materials: powdered clay, stinger tooling, mallet, ramming post, ¼-teaspoon measuring spoon, paper tube, and an awl.

Note: The powdered clay is rammed dry. It will tightly pack into a solid mass during the ramming. Never dampen this clay.

If you are using the Combo-Tool, place the paper tube on the middle-length spindle on the tooling base. This spindle will create a hole through the clay nozzle, and a core up into the stinger's fuel grain.

Install the ram-through funnel on the top of the paper tube. Scoop out a slightly rounded ¼-teaspoonful of the clay and dump it into the tube through the funnel.

Place the Combo-Tool base on a solid ramming post (like a 4 x 4 post). Insert the hollow ram-drift. Slide it up and down in the tube a few times to completely settle the clay to the bottom of the tube. Gently ram (hammer) the hollow drift 6-8 times with the mallet until the clay nozzle feels completely solid.

Ramming a Clay Nozzle in a Stinger Missile Tube

(click image to play video)

Remove the drift from the tube and clean any clay out of the hole in the drift with an awl.

Holding the spindle base and tube in one hand, tip them over and gently tap any loose clay out of the tube back into the container of clay.

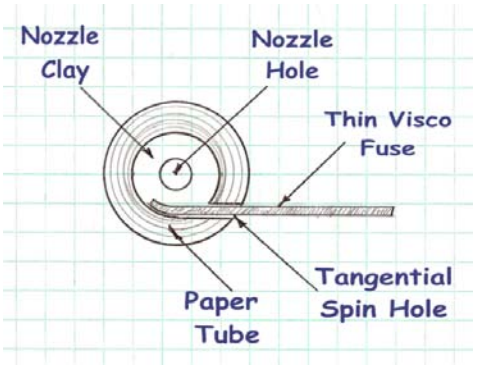
There is now a nice, solid nozzle formed in the rocket tube.

Drilling the Spin Hole in Tube and Installing Fuse

The spin hole has to be drilled tangentially, at the angle shown in the diagram below. Otherwise, the rocket won't spin. That hole accommodates a piece of thin-Visco fuse used for ignition and vents the exit gas, which spins the rocket for stability.

Note: A tangential line intersects the curve of a circle perpendicular to the radius of the circle at that point. If that's Greek to you, check out the diagram below.

Unlike other rockets, a stinger missile is ignited through a hole in the side of the paper tube just above the nozzle. Looking down into the tube from the top, you can see that the hole is not drilled straight/perpendicularly into the side of the tube. If you drill straight in, the tube won't spin.



Looking Down Stinger Tube at Spin-Hole and Fusing

This side-fusing arrangement ignites the stinger fuel just inside the spin-hole first. The burning gases spew out of the side hole, spinning the stinger on its launching post, providing gyroscopic stability to the rocket.

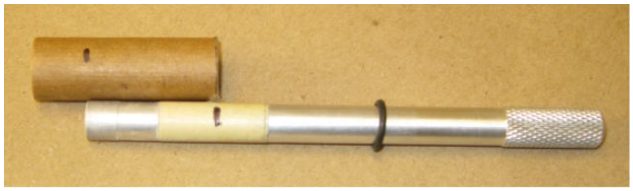
Then the fuel burns through to the main cavity that was formed by the spindle in the middle of the fuel grain. That area in the middle of the fuel ignites and shoots the lift gasses from the bottom of the motor while the spin-gases continue to turn the motor.

The rocket rises into the air, still spinning.

So, how do you get this tangential spin-hole in just the right place and angle? Here's how you do it.

Remove the tube from the spindle. Insert the hollow rammer until it bottoms out on the nozzle. Put a pencil mark on the rammer where the top of the tube is.

Remove the rammer and place it beside the tube, with the mark aligned with the top of the tube. Put a mark on the side of the tube where the bottom of the rammer is. That is where the top of the clay nozzle is inside the tube.



Marking the Spin Hole Location

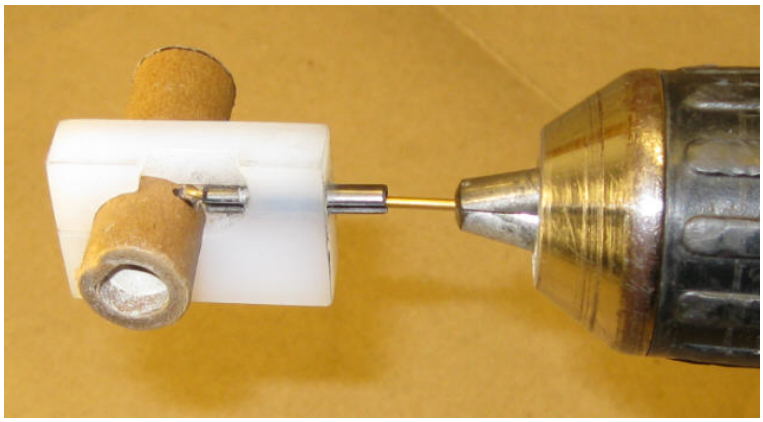
The hole should be drilled just above that mark. Mark exactly where the hole will be drilled by sticking an awl slightly into the side of the tube to create an indentation there.

Denting Tube Where Spin Hole Will Be Drilled

Install the white plastic drill guide over the tube. Align the metal guide so it is pointing right at the dent in the tube.

With one hand, use your fingers to clamp the drill guide tight against the tube. With your other hand, gently drill a 1/16-inch diameter hole through the tube wall. Let the drill guide control the angle of your drilling. Drill only deep enough for the bit to just pierce the inside of the tube wall. Be careful not to drill far enough to pierce the other side of the tube.

With the drill running, move the bit in and out a couple times to clean out the hole.



Drilling a 1/16-Inch Spin Hole Using the Drill Guide

(click image to play video)

Insert a 3-inch-long piece of thin-Visco fuse until you can see the fuse inside the tube, skimming along the tube's inside wall about 1/8 inch. Bend the fuse over against the tube's outside wall and tape it there.

Thin Visco Fuse Installed in Stinger Tube

(click image to play video)

Put a No-Pass Mark on Solid Rammer

Put the stinger tube, with the nozzle rammed in it and fuse installed now, back onto the correct spindle (if you're using the Combo Tool, it's the center one).

Insert the solid rammer all the way into the tube until it contacts the tip of the spindle.

Put a pencil mark on the rammer where the top of the tube is.

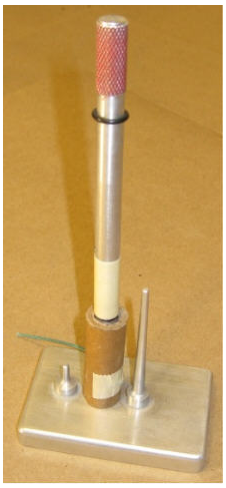
Marking Solid Rammer at Top of Tube

Pull the drift out of the tube and put another pencil mark on the rammer ¼-inch below the first mark.

Marking the Rammer ¼-Inch Below First Mark

Put a piece of masking tape around the solid drift with the bottom edge of the tape aligned with this second pencil mark.

This bottom tape-edge is the “no-pass” point beyond which the solid rammer is never rammed into the tube.

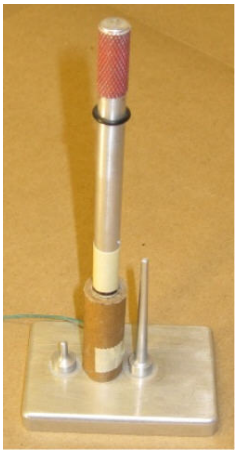


Bottom Edge of Tape Aligned with Second Mark

Put a Top-of-Spindle Mark on Hollow Rammer

Slide the solid rammer, with the no-pass tape on it, all the way into the tube until it contacts the tip of the spindle.

Make a mark on the tape at the top of the tube.

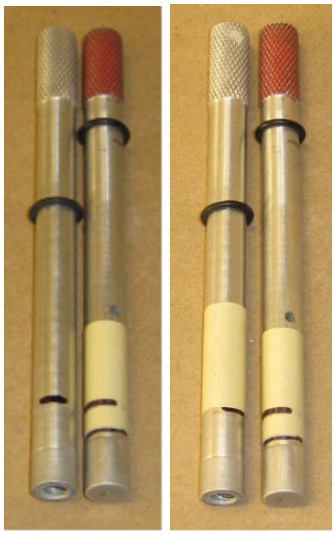


Putting Mark on Solid Rammer's No-Pass Tape at Top of Tube with Rammer in Contact with Spindle

Pull the solid rammer out of the tube and align its bottom end with the end of the hollow rammer. Put a mark on the hollow rammer in the same place the mark is on the tape on the solid rammer.

Now, wrap a single layer of tape around the hollow rammer with its bottom edge aligned with the mark on the rammer.

The lower edge of the tape on the hollow rammer shows how far it would be down in the tube when its end is even with the tip of the spindle.



Putting a "Top-of-Spindle" Line on Hollow Rammer

Note: If the hollow rammer will not slide into the paper tube once this piece of tape is on it, use a black Sharpie marker to make a mark where the bottom of the

tape is and remove the tape. Keep an eye on the Sharpie mark as you are using the hollow drift, and refresh the mark as it gets worn off.

Ramming the Stinger Missile Fuel

Make sure the paper tube, with nozzle and fuse installed, is on the correct spindle. Install the ram-through funnel on the tube.

Load ¼-teaspoonful of stinger missile fuel into the paper tube through the funnel. Using the hollow rammer, compact the fuel with 6-8 hits with the mallet.

Repeat this with increments of fuel and the hollow rammer until the top-of-spindle mark on the rammer is even with, or above, the top of the tube after a fuel increment has been rammed.

Now, switch to the solid rammer. Continue to ram the same ¼-teaspoon increments of fuel in the tube until there is only ¼-inch of empty space left at the top. Make sure the no-pass line on the solid rammer never goes past the top of the tube to ensure that it never gets close to coming in contact with the spindle.

Loading Fuel to be Rammed in Stinger Missile

Ramming a Clay Bulkhead

Put a ¼-teaspoonful of powdered clay into the funnel and tamp the clay down with the solid rammer, filling the end of the tube as much as possible by hand.

Ram this clay solid with the solid rammer to create a bulkhead in the end of the tube.

Ramming Clay Bulkhead in Stinger

(click image to play video)

Installing a Heading on the Stinger Missile

A heading will ignite at the end of the stinger's flight, finishing it off with an extra pyrotechnic effect.

Remove the funnel from the stinger missile, and gently twist the motor to remove it from the spindle.

For the stinger fuel to ignite the heading, a passfire hole must be drilled through the clay bulkhead.

Using a 1/8-inch drill bit, center the bit in the face of the clay bulkhead and gently twist the bit by hand, drilling into the clay and keeping the bit perpendicular to the bulkhead face. Drill just deep enough to penetrate the rocket fuel. Dump the loose clay and fuel out of the tube.

Hand Twist-Drilling 1/8-Inch Passfire Hole in Bulkhead

Wrap a 4.5-inch long piece of 1-inch wide masking tape around the top of the paper tube, with a 1/4-inch width of the tape stuck to the tube and ¾ inch hanging over the end.

Wrapping Masking Tape on Top End of Stinger Tube

Drop enough stinger fuel into the end of the masking tape cylinder to fill the passfire hole plus just a little more fuel. This is about 1/8 teaspoon of fuel, or even a little less.

Putting Loose Stinger Fuel in Top End of Stinger Missile

Drop a single 3/8-inch pumped star in the tape-heading enclosure. Fold the tape closed over the star, and apply a 1-inch by 1-inch piece of masking tape to seal the heading end. An alternative to using the star is to simply mix a little ferro-titanium with the loose fuel inside the heading nosing to add a bright spark effect.

Adding a Star to the Heading; Sealing the Heading with Masking Tape

(click image to play video)

Making a Launching Platform for Stinger

These little missiles get launched off of a “pin” stuck in a wood base. The launch pin has the least spin resistance if it’s sharp on the end, and a little smaller in diameter than the tip of the spindle, which created the core in the stinger motor.

That way the stinger can spin freely once the fuse ignites the fuel inside the spin hole, and then rise easily off the pin when the fuel inside the core ignites.

A long thin nail, a section of wire coat hanger in a piece of wood can work as a launching platform. File the tip of the nail smooth to reduce friction and fuel abrasion.

An ideal launch platform is a block of wood with a round toothpick stuck in a 3/32-inch hole drilled in the block.

The toothpick is easily replaced if it is lost or damaged. And if it falls out of the block of wood in your backyard, you don’t have to worry about hitting it with your lawnmower.

Make sure to leave enough of the toothpick sticking out of the wood that the stinger can sit on it without its bottom hitting the block of wood. If your stinger was made using the Combo-Tool, a 1.5-inch long launch pin sticking out of the wood is ideal.

Stinger Launch Pad: a Block of Wood and a Round Toothpick

Launching a Stinger Missile

Set the launching pad up in a safe location. Put the stinger on the launch pin, ignite fuse, retire and enjoy! Repeat the process until satisfied, if that is possible.

Stinger Missile Launching

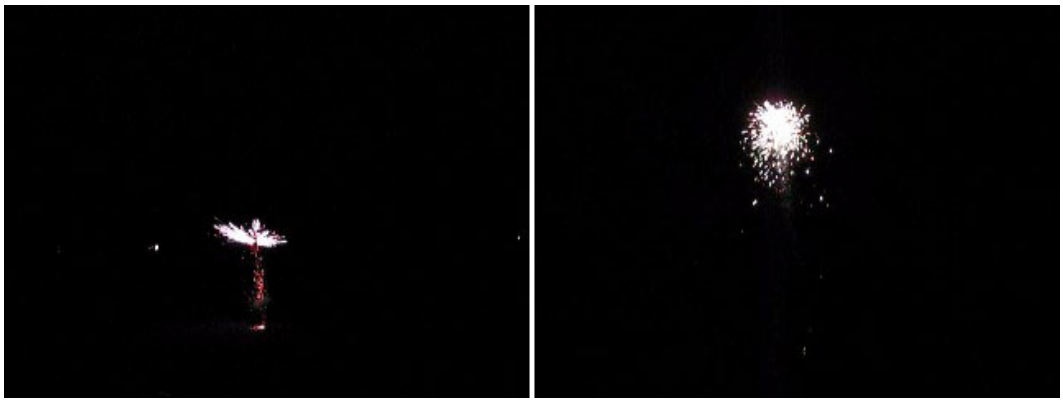
(click image to play video)

Caution: Stingers can fly sideways if you load too much weight in the heading, or make them too long, or launch them in the wind.

Chapter 14: Making Hummers and Whirlwinds (Make 5 Hummers & 5 Whirlwinds)

Not sure what hummers and whirlwinds are?

They are spinning aerial tube devices, which make sparks and a really entertaining noise. Some all-time favorite consumer fireworks cakes utilize these two effects. Texas Cyclone is a classic example of the whirlwind effect; and Wild Boar/Bear never fails to get the audience laughing with the humming inserts they fire skyward which then zip across the sky.



Ferro-Titanium Hummer and Whirlwind

(click image to play video)

Hummers and whirlwinds are basically small tubes with composition rammed in them. Vent holes are drilled in the tubes so that the tubes spin either on the long axis (hummers) or end-over-end (whirlwinds).

These devices can be shot individually out of small mortars, as seen above, or multiples of them used in aerial shells.

Their composition can spray either charcoal–or metal sparks such as ferro-titanium. You can clearly see the two different spark effects in the video above.

Making Hummers and Whirlwinds

Before you begin: This project utilizes the black-powder base mix described in Chapter 7 (if you have not made up your base mix yet, go here first).

You will also need 5 of the 3/8” ID x 3.5” long tubes.

Mixing the Hummer/Whirlwind Fuel

The fuel for these devices is made by adding some 80-mesh charcoal and some ferro-titanium, if desired, to the black-powder base mix.

Hummer/Whirlwind Fuel Formula (enough for 10 devices)

Chemical	Percentage	1.4 ounces	40 grams
Black-powder base mix	0.86	1.2 ounces	34.4 grams
80-mesh charcoal	0.05	0.07 ounces	2 grams
Ferro-titanium, 60-100 mesh	0.09	0.13 ounces	3.6 grams
Total	1.00	1.4 ounces	40 grams

Note: Ferro-titanium produces silverish sparks. If it is omitted from the formula, the devices will perform with a soft, orange spark display instead.

To make a batch of the fuel, weigh each component into its own paper cup. Then combine the ingredients into one cup and reweigh it to make sure the total weight is what is shown above. This verifies no mistakes were made during the weighing.

After you have confirmed the correct weight, pour the chemical mixture from the cup into a mixing tub. Install the lid tightly on the tub, and holding the lid on tight, shake the tub to thoroughly mix the fuel.

Using a Sharpie marker, label the fuel in that tub and keep the fuel in the closed tub during device construction, opening it only to remove each necessary increment of fuel.

Cutting Paper Tubes

These hummers and whirlwinds use 3/8-inch ID x 1.75-inch-long paper tubes. If you're starting with a 3.5-inch long tube, it must be cut in half to produce two of the tubes you'll need in this project. Cut 5 tubes in half, which will yield 5 finished hummers and 5 whirlwinds.

Measure 1.75 inches from one end of your tube and mark that point at the tube's middle.

Cut the tube in half at the mark, using a sharp saw and a miter box to produce nice, square, clean cuts.

Cutting a Paper Tube in Half with Hand Miter Box and Saw

(click image to play video)

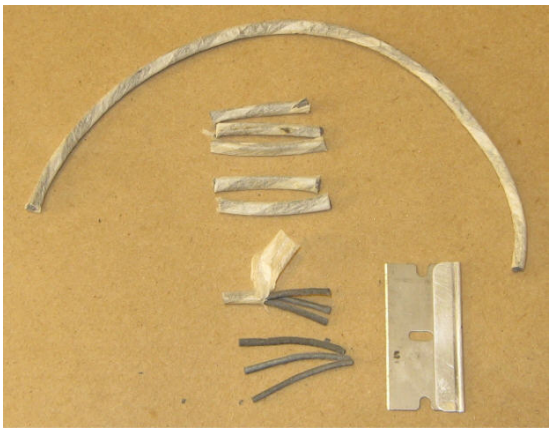
Cutting 1-Inch Pieces of Thin Blackmatch

For the ignition fuses in the hummers and whirlwinds, 1-inch-long pieces of thin black match (1/16-inch diameter or smaller) will be needed.

If you have Chinese quickmatch or Skylighter's paper-wrapped fast fuse, there are strands of this thin blackmatch fuse in it.

Cut seven, 1-inch-long pieces of the paper-wrapped fast fuse with a sharp razor blade or razor-anvil cutter.

Remove the paper wrapping from each length of fuse to harvest 21 pieces of thin blackmatch.



Harvesting Blackmatch from Paper-Wrapped Fast Fuse

Constructing Hummers and Whirlwinds

Although these two types of devices both use the same tubes, fuel, fuse, and basic construction techniques, there are some basic differences between them, which cause their very different performances.

So, here is how to make each type.

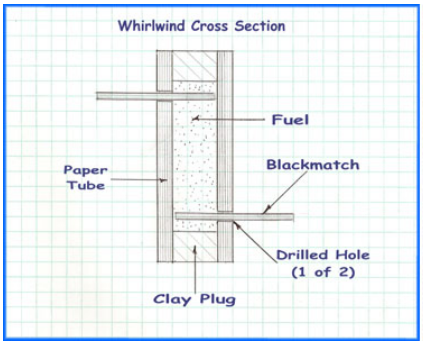
Making Hummers

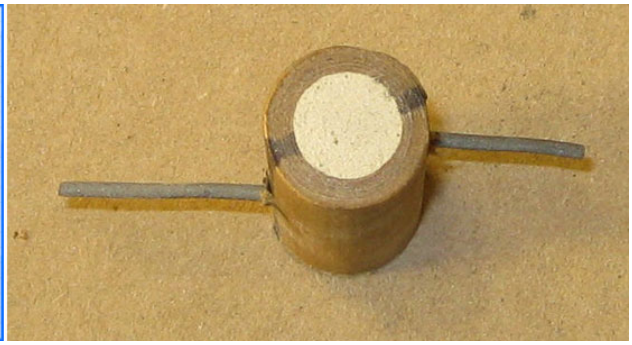
A hummer has fuel rammed between two clay end plugs in a paper tube.

It has two, tangential spin-holes in the middle, and on opposite sides of the tube. Fuses are inserted into these holes as the fuel is rammed. This holds the fuses solidly in place in the fuel grain.

These fuses are ignited as the hummer is launched out of its mortar. The gasses spewing from the spin holes twirl the hummer rapidly on its main axis, creating a halo of sparks and a unique whirring sound.

Here's what a completed hummer looks like.





Hummer Construction

(click image to play video)

Marking Hummer Spin Holes

First, put a line straight down one side of a 1.75-inch-long tube. On one end of the tube, put a mark where that line is. Put another mark opposite the first one on the end of the tube. Put a line straight down the other side of the tube lined up with that second mark. This results in two lines running lengthwise on the tube, and on opposite sides of it.

Measure half way down each line, and make a mark. These two marks are where the spin holes will be drilled.

Marked Hummer Spin-Hole Location (Same Mark on Both Sides of Tube)

Ramming a Clay Plug

Put a 1-inch square piece of masking tape on one end of the paper tube to temporarily seal it.

Put the ram-through funnel on the open end of the tube.

Load a flat ¼-teaspoonful of powdered clay into the tube through the funnel.

Note: Clay is rammed dry. It will tightly pack into a solid mass during the ramming. Never dampen this clay.

Stand the tube up on the aluminum ramming base. The base should be sitting on a solid ramming post. Insert the solid ramming drift. Slide the drift in and out of the tube several times to compact the clay at the bottom of the tube.

Tooling Ready to Ram Clay Plug

Ram the clay plug solid with 8 light hits with the mallet.

Remove the drift from the tube, and dump any loose clay back into its container.

This should produce a ¼-inch tall clay plug in the tube. Measure it to see. As you work on these devices, fine-tune the volume of your increments to achieve this ¼-inch thickness.

Ramming Half of the Fuel in the Paper Tube

Place the tube back on the ramming base, and load a flat ¼-teaspoonful of fuel into the tube through the funnel.

Ram this increment of fuel solid the same way you did with the clay plug.

Remove the drift, put another increment of fuel into the tube, and ram it solid, too.

This should bring the level of the fuel up to just a little below the halfway point of the tube. Once again, fine tune and adjust the size of your increments so that you achieve this level with just two increments of the fuel.

Drill Spin Holes in the Tube

Hummer spin holes must be drilled tangentially--at an angle--for the device to spin. Your hummer will not work if the holes are drilled perpendicularly into the tube. Look at the Hummer Cross Section diagram above to be sure you understand how these holes are drilled.

Warning: You are about to drill through the paper tube very close to or into a pyrotechnic composition, which may have metal in it. Perform this operation:

Wearing eye protection, leather gloves, and cotton clothing

Outdoors

Away from any exposed, loose pyrotechnic compositions

Slowly

Carefully

With a very sharp or new 3/32-inch drill bit

Remove the funnel from the tube. Using a sharp awl, make indentations at the spin hole locations.

Install the white plastic drill guide on the tube and align it with the metal guide tube pointing at one of the spin holes.

With one hand, squeeze the drill guide to hold the tube tight. With your other, drill a tangential spin hole through the tube's wall until the drill bit just penetrates the inside of the tube. The drill guide will produce the proper angle for you.

Drilling Hummer Spin Hole with 3/32-Inch Bit and Drill Guide

Remove the drill bit from the tube.

Rotate the drill guide around the tube until the metal guide tube is pointing at the other spin hole location.

Drill a spin hole at that location, too.

Installing Blackmatch and Ramming the Rest of the Fuel

Insert a 1-inch-long piece of blackmatch into each of the spin holes until they are in as far as they will easily go.

Put the funnel back on the tube.

Ram increments of the fuel until there is only ¼-inch remaining empty at the top of the tube.

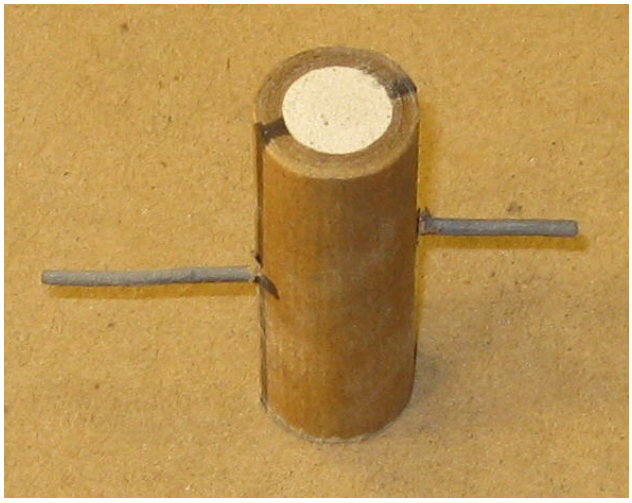
Dump any loose fuel back into its container, and close it tightly.

Ramming the Top Clay Plug

Remove the funnel, and plunge the open end of the tube several times into the powdered clay until the end is filled with a bulging increment of the clay.

Ram this final clay plug solid with 8 hits of the mallet.

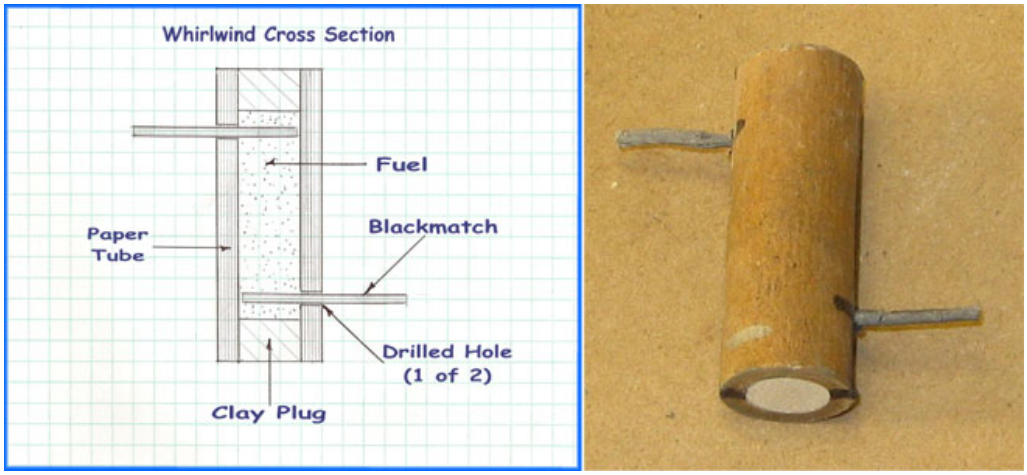
Remove the temporary masking tape, and the hummer insert is completed.



Completed Hummer

Making Whirlwinds

Whirlwinds are similar to hummers. But the holes are drilled perpendicularly into the tube, and are located at each end on opposite sides. So, where a hummer comes out of the mortar spinning on its main axis, whirlwinds fly skyward twirling end-over-end, creating a cyclonic spray of sparks.



Blackmatch in Holes of a Whirlwind

(click image to play video)

Marking Whirlwind Holes

Mark lines 180 degrees apart, running lengthwise on the whirlwind tube, just as you did for a hummer. On one line measure 3/8-inch in from either end of the tube and put a mark there. Put a mark on the opposite line 3/8-inch in from the other end.

Marked Whirlwind Hole Location (Mark on Line on Other Side is 3/8-Inch from Other End)

Ramming a Clay Plug in One End of the Tube

Just as you did with the hummer, ram a clay plug in one end of the whirlwind tube.

Drilling the Fuse Hole Nearest the Clay Plug, and Inserting Fuse

Drill the fuse hole at the mark nearest the plug you just rammed. Drill the hole with the 3/32-inch bit, perpendicular to the tube. Do not use the plastic drill guide. Drill this hole straight through the tube wall.

Insert a piece of the blackmatch into this hole until it hits the other side of the tube.

Ramming Fuel Increments

Ram ¼-teaspoon increments of the fuel, just like in the hummer, until the fuel comes up to just a little under the place where the second, top fuse hole is marked.

Drilling the Second Fuse Hole, and Inserting Fuse

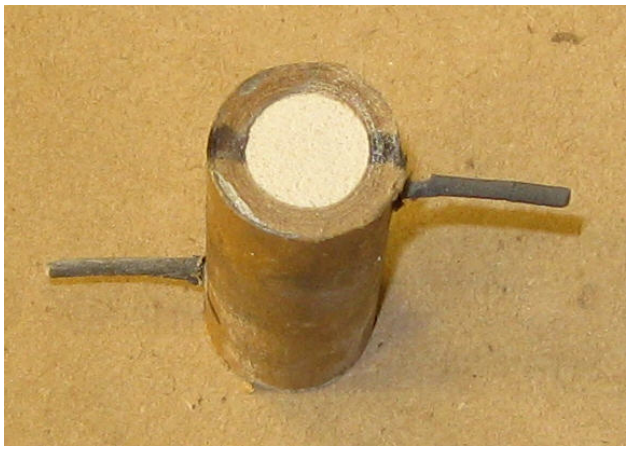
Exercising the same caution as before, drill the second fuse hole. Insert a piece of the blackmatch in that hole.

Finish Ramming the Fuel

Ram the final fuel until there is only ¼-inch left empty in the tube. Dump any loose fuel back into the cup; return the unused fuel to its tub and tightly close it.

Ramming the Final Clay Plug

Ram a clay plug in the top of the tube, as you did when finishing the hummer.



Completed Whirlwind

Launching Individual Hummers and Whirlwinds

Individual hummers or whirlwinds can be loaded into, and launched from ¾-inch ID mortars. That process is fully described in the "Flying Fish Fuse" project in Chapter 5.

Simply follow all the steps in the "Assembling a Flying Fish Fuse Mine" section of that chapter. The only difference is a hummer or whirlwind will be loaded in the mortar instead of a bundle of flying-fish fuse.

Assemble a ¾-inch ID mortar.

Insert a 3-inch piece of Visco ignition fuse into a hole at the base of the mortar tube.

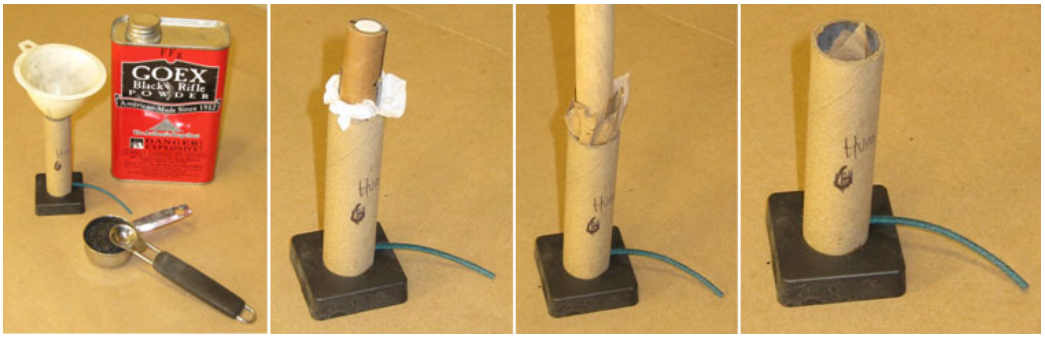
Put 1.5 grams of FFg black powder, or 3.5 grams of Hodgdon 777 black powder substitute into the mortar to serve as the lift charge.

Wrap the bottom end of one of the hummer or whirlwind inserts with a small piece of tissue paper, keeping both pieces of blackmatch pointing downward. The tissue will keep the black powder in its position even if the device is tipped over during transportation. Pointing the fuses downward helps the device take as much fire as possible when the lift powder ignites.

Put the insert into the mortar, and push it all the way to the bottom so that it is seated on top of the lift powder.

Insert two 1.5-inch squares of paper on top of the insert inside the mortar. These pieces of paper protect the contents of the mortar from falling sparks from other fireworks as they go off, and they also help build up pressure before the contents are fired into the air.

Mark the mortar with the effect it contains.



Loading Mortar with Lift Powder and Hummer Insert

(click image to play video)

Put mortar on a flat surface in a safe location, light fuse, retire and enjoy!

Note: You can make a fun multi-shot “cake” from hummers and/or whirlwinds in the same way a cake was made with flying fish mines at the conclusion of that chapter.

Chapter 15: Making Festival-Ball Aerial Shells (Make 5 Shells)

Admit it. Don't we all just wanna be able to make a nice little aerial shell?

Fired alone--one after another or as the heading on a rocket--aerial shells are what most of us think of when we imagine "fireworks."

Festival-Ball Shell Lifting Off and Displaying in the Sky

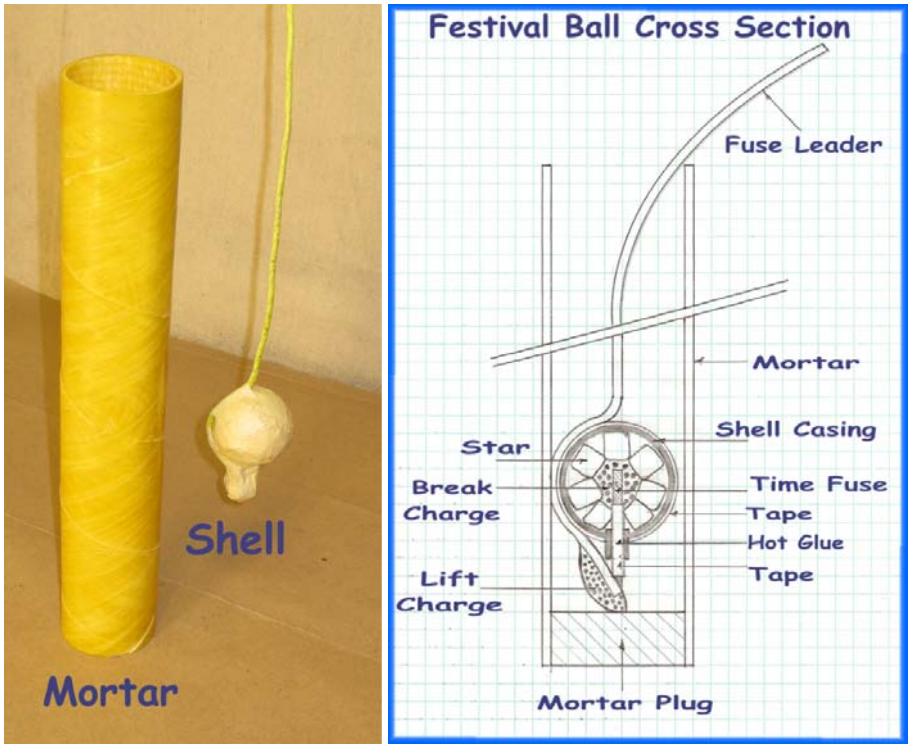
(click image to play video)

First it's important to understand the distinction between a "shell" and its "mortar:" An aerial shell, a projectile, is fired out of a mortar, a tube.

A consumer fireworks mortar can be made of paper, fiberglass, or HDPE plastic. (Never use PVC plumbing plastic pipe—it's dangerous.)

A typical fireworks shell should have a clearance in the mortar of approximately 5% if its diameter. This is important. If you have too much clearance, your shell may not be propelled high enough in the sky, and could start fires or injure someone. Too little clearance, and your shell won't fall freely to the bottom of the mortar when you load it. Or too much pressure can be created in the mortar under the shell when the lift powder is ignited, possibly causing a mortar rupture and/or a dangerous explosion.

If you have too much clearance you can make up for it with a little more lift powder or by adding layers of tape to the outside of your shell.



Fiberglass Mortar and Festival-Ball Shell

Making a Festival-Ball Fireworks Shell

Before you begin: This project utilizes the 3/8-inch pumped stars described in Chapter 5. If you have not made those yet, go here and make them now. If you have flying-fish fuse left over from the mine project in Chapter 6, it can be used in these shells instead of stars. Or you can use a combination of stars and fish fuse.

Now is a good time to plug your hot-glue gun in and get it heated up and ready to go when you need it.

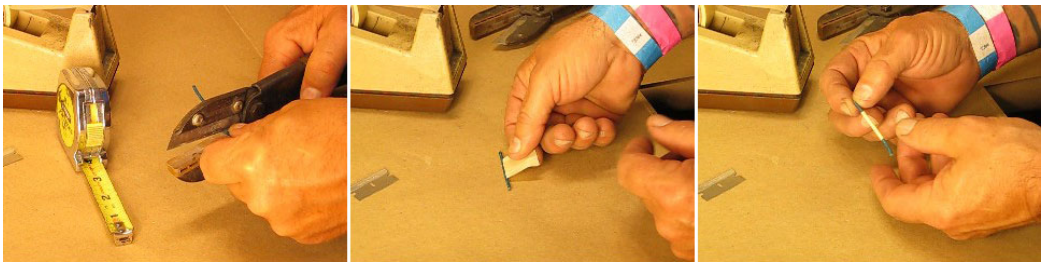
Warning: Hot-glue guns, especially cheap ones, have been known to malfunction and spit sparks out of their sides. It is safest to plug the gun in at a remote location isolated from any area where you are working with pyrotechnic materials. Just before you use the gun on a fireworks device, unplug it and use it while it is still hot but has no electricity flowing through it. Never have a plugged-in hot-glue gun sitting on a workbench near flammable materials.

Preparing the Time Fuse for the Shells

Green Visco ignition fuse will be used as the time fuse in these shells.

Using a razor blade or razor-anvil cutters, cut a 2-inch piece of Visco fuse.

Tightly wrap a 1-inch square piece of masking tape around the middle of the Visco fuse.



Cutting and Tape-Wrapping Visco Time Fuse

(click image to play video)

Installing Time Fuse in the Shell Casing

Slide the masking-tape-wrapped Visco time fuse in and out of the fuse hole in the shell half to make sure it fits. The wrapped section of the fuse should slide easily into the hole, but there should no room for it to wiggle from side to side. Adjust the masking tape wrap to make the fit just right.

Now, unplug your hot-glue gun.

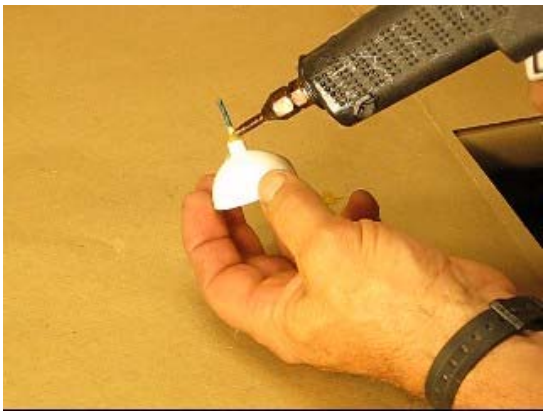
Run a thick bead of hot-glue around the time fuse right in the middle of the masking-tape wrap.

While the glue is still hot, from the inside of the casing, insert the time fuse into the hole in the shell casing until ¼-inch of the masking tape wrap is sticking out beyond the outside of the shell casing nipple. This seals the fuse on the inside of the shell.

Hot-Gluing Time Fuse into Shell Casing

Run a bead of hot-glue around the masking-tape-wrapped time fuse right where it projects from the outside of the shell casing.

This provides a solid hot-glue seal on the outside of the casing around the time fuse. The outside seal is necessary to prevent fire from entering the shell when it is launched, causing it to explode in the mortar.



Hot-Glue Sealing Outside Time Fuse

(click image to play video)

Filling Shell Half with Stars and Break Charge

Place the solid shell casing half on a little stand, such as the drill guide or funnel from the Combo-Tool kit, and on a paper plate to catch any contents that might spill.

Line the shell half with a single layer of stars until they just start to project past the top edge of the casing.

Fill the void in the middle of the layer of stars with Goex FFg sporting grade black powder until the powder starts to mound up in the middle of the layer of stars.

Add a few more stars on top of the mound of break charge, leaving the top middle open so the time fuse can be inserted into it.

Filling Shell Half with Stars and Break Charge

(click image to play video)

Gluing the Halves of the Shell Casing Together

Note: PVC plumbing cement emits toxic fumes as it dries. Do the following procedure in a well-ventilated area. Do not breathe these fumes for extended periods. Follow the precautions on the can.

Using a Q-Tip, apply PVC plumbing cement to the recessed joints in the two halves of the shell casing.

Applying PVC Cement to Shell Casing with Q-Tip

Lower the fuse half of the shell onto the bottom half. Carefully push the end of the time fuse down into the burst charge, and twist the two halves into each other.

Closing and Twisting Glued Shell Halves Together

Press the two casing halves together and twist them until they are completely closed, squeezing melted plastic out of the equatorial joint.

As you hold the two halves tightly together, apply pieces of masking tape over the glued joint.

Applying Masking Tape over Glued Shell Casing Equator

(click image to play video)

Applying Reinforcing Tape to Shell Casing

The stronger and more tightly joined a shell like this is, the better it will look when it bursts in the sky. The glued shell casing you have at this point is not yet strong enough to create a nice shell burst. Reinforcing the casing with some fiberglass filament strapping tape will greatly improve the shell strength and star burst radius.

Apply 4 bands of ½-inch wide strapping tape to the shell, evenly spacing the bands over the surface of the shell casing.

2-inch wide, Scotch Strapping Tape “For Heavy Jobs” is perfect for this job. Split the end of this tape ½-inch from the edge and it will tear off in a half-inch wide strip.

Apply one band, two layers thick, around the shell, with the band crossing the fused end just to one side of the time fuse nipple.

Rotate the shell 120 degrees and repeat this.

Rotate the shell 120 degrees and repeat again.

First 3 Bands of Strapping Tape on Ball-Shell Casing

Put the final, fourth, band, two layers thick, around the equator.

Finish this tape reinforcement off with a layer of masking tape covering the entire surface of the shell.

Burnish the tape layers down by rubbing the shell's surface with a round, smooth object like a Sharpie marker.

Strapping Tape Band 4 and Masking Tape Layers

(click image to play video)

Assembling Shell Leader Fuse and Lift Charge Bag

Cut a 15-inch piece of yellow fast-Visco fuse, which will serve as the “leader” (fuse) for this shell.

Put 3.5 grams of Goex FFg sporting black-powder into the corner of a thin plastic sandwich baggie. With the baggie bunched around the lift powder, clip that baggie corner off at a length of 2 inches.

Bend one end of the fast-Visco fuse leader into a hook, and insert that end into the lift powder in the baggie.

Use masking tape to secure the baggie of lift powder to the shell leader, and to completely close the baggie around the fuse. The hooked end of the leader must be in the black powder.

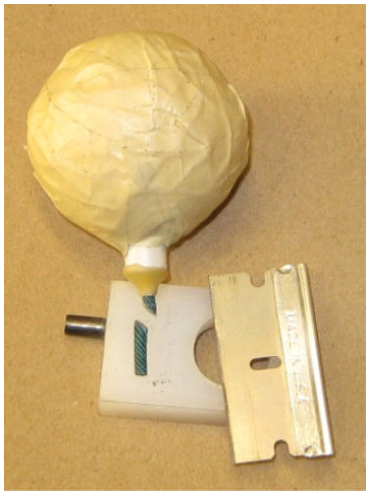
Assembling Lift Powder Baggie and Shell Fuse Leader

(click image to play video)

Attaching the Fuse Leader and the Lift Charge Baggie to the Shell

Use a sharp razor blade to cut the green visco time fuse on a sharp angle right next to where its masking tape wrap begins. Use the Combo-Tool drill guide as a cutting block beneath the fuse.

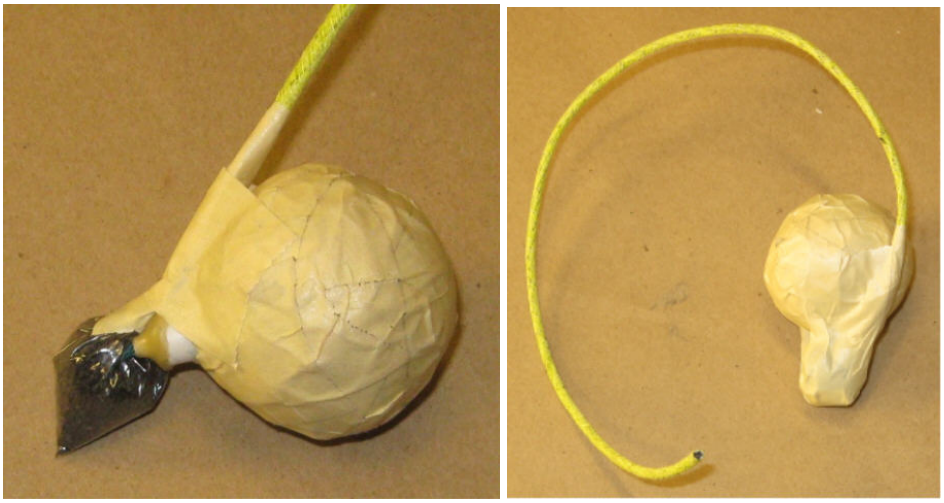
Cutting the fuse on an angle exposes as much of the fuse's inner core of black powder as possible to enhance its chances of ignition when the shell lifts out of the mortar.



Cutting Visco Time Fuse at a Sharp Angle

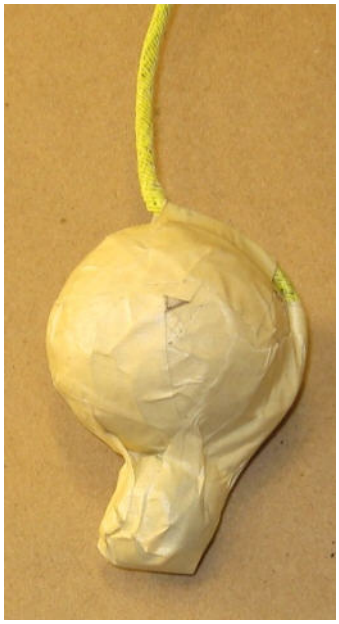
Now push the baggie of lift powder right up against the time fuse, and attach it using a piece of masking tape.

Cover the lift powder baggie with masking tape.



Taping the Leader and Lift Charge to the Bottom of the Shell

Now pull the leader to the top of the shell and tape it to the shell so the leader comes off the very top of the shell if it is hanging from the leader.



Completed Festival Ball Shell, Leader Taped to Top

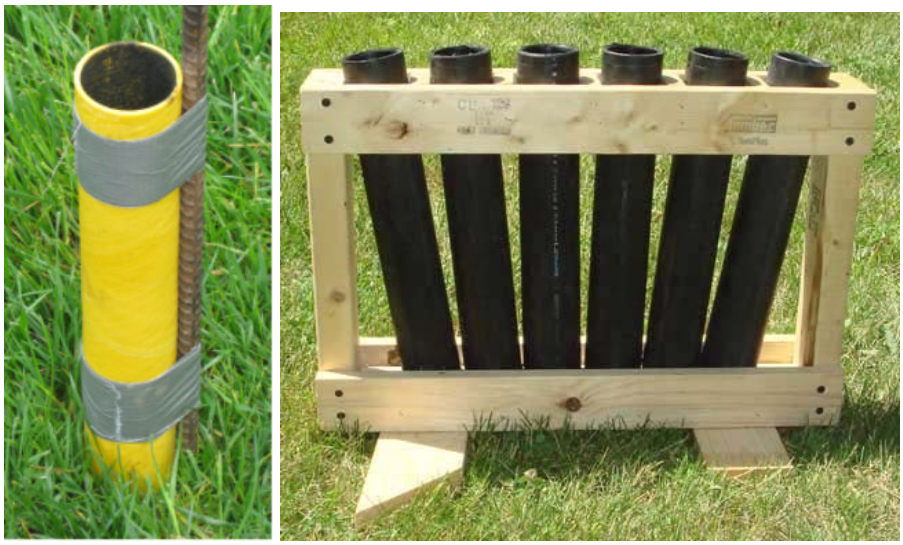
(click image to play video)

Securing the Mortar to Launch the Shell Safely

Your mortar needs to be solidly locked in place before you fire a shell out of it. Otherwise the launch explosion can easily tip the mortar and fire the shell someplace you don't want, such as at YOU!

To safely secure a single mortar tube for shell launching, attach it to a wood or metal stake that you've driven into the ground. If the shells are to be launched from a driveway use a wood support base, or other assembly, for the mortar.

For multiple mortars, a rack will safely support them.



Safe Setup for Individual and Multiple Mortars

Always remember if you are firing from and reloading a mortar, there can be burning embers in it from the previous shell. Let the mortar cool down. Clean any debris out of it with a wooden stick with a nail in it. Debris left in the mortar can prevent the next shell from going as high as it is supposed to and causing what is called a "low break." Low breaks cause injuries, fires, and any remaining fireworks in the area to be prematurely ignited.

Reload Shells with the Utmost Caution

Never put any body part over a mortar when you are loading and firing a shell from it. One of these shells could easily kill you if it launches into your head, or it could remove your hand if it is over the mortar when the shell fires.