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Volume 4, Issue 3

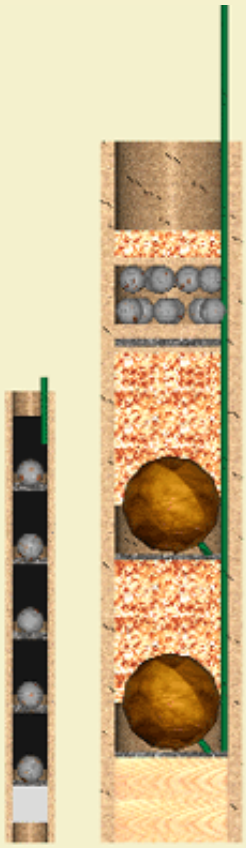
Build This...

Roman Candles

*by **Michael Fales***

Summary:
For many people, the Roman Candle was their introduction to the magic of pyrotechnics at a young age. The long wands have an almost wizard like quality as they shoot flaming, colorful balls of fire through the air one after the other. These are among some of the earliest projectile type devices produced, and the traditional construction method has changed little over the years.

Two methods of candle construction are described here: the traditional small caliber type commonly sold for consumer use, and the large caliber type that are usually Class B items used for commercial shows.



Materials (small bore):

- 8" long 5/8" ID - 1/8" wall convolute wound tube
- 1/2" stars (round or pumped)
- Safety fuse (visco)
- Large wooden skewers
- Fiber tape
- 20-30 lb kraft paper
- PVA glue
- String
- 2FA black powder
- Candle delay composition
- Fire clay or bentonite

Tools (small bore):

- 5/8" x 8" long rammer

Materials (large bore):

- 2" ID x 24" long tube, 3/16" thick wall
- Safety fuse (visco)
- 2Fg black powder
- Wood glue
- Hot glue
- 20-30 lb kraft paper
- 4-1/2 cups fine sawdust
- Five 2" corrugated cardboard disks
- 1/2 cup 3/8" to 1/2" stars
- Four 1-3/4" ball shells

Tools (large bore):

- 24" long tamping stick approx. 3/4" square
- Measuring cup
- Measuring spoon set

- 5/8" rammer notched for fuse
- Non sparking ramming mallet
- Ramming block with 5/8" diameter nipple
- Funnel and measuring spoons
- 1/8" drill bit
- Electric drill
- Hot glue gun

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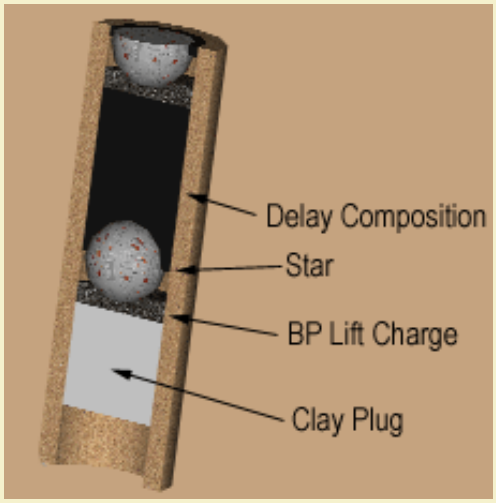

Figure 1: Components of a Roman candle shot.


Figure 2: Materials for building a 5/8" candle.

Project 1: Traditional Candle

In it's simplest form, a one shot roman candle can be a small amount of lift charge at the bottom of a tube with a star placed above it. The lift charge is ignited, possibly by a bottom fused piece of black match or alternately by a piece of black match inserted into the tube, and the star is blown from the tube and burns as it travels through the air. This simple device is also commonly known as a "star tester," since it is the preferred method of testing individual stars after they are produced.

A true roman candle features multiple shots stacked on top of each other, which fire with a controlled delay between shots. The delay is created by ramming a slow burning black powder composition, known as the "delay composition," between each star/lift increment (see Figure 1). The delay comp burns until it reaches the star, which is usually a meal primed star or it can also be an unprimed star with fast burning meal rammed around the outside of it. The fast burning meal allows the flame propagation to race around the star and ignite the lift charge before the star has much time to burn in the tube. After the lift charge launches the star out of the tube, the next segment of delay composition burns until the process repeats itself.

This first candle described here is of the smaller variety most commonly seen in the class C market. There is no real perfect number of stars to shoot, but 5 to 8 shots is a good place to start. The longer a candle becomes, the harder it is to create. There is also a greater chance of the candle misfiring as its length increases. I have seen commercial 100 shot "California candles" several feet long burn erratically, shooting dozens of shots at once or just outright splitting down the side. Not only are long candle tubes hard to properly load, they are difficult to roll or find on the market.

Common sizes for commercial candles are 3/8" and 1/2" I.D. tubes. The procedure shown here is standard for candles in the 1/4" to 3/4" range, so feel free to change the dimensions. The candle shown here will use a 5/8” I.D. tube that shoots 1/2" diameter stars. Thus you will need a 5/8" I.D. convolute wound tube with a 1/8” wall thickness and a length of 8". You will also need a ramming block with a 5/8" diameter nipple protruding at least 1/4" to load the candle tube on, as seen in Figure 2. This base is not entirely necessary, as the tube can be loaded with the clay plug flush to the end of the tube, but using a nipple helps hold the tube while you are working and also results in a clay plug that is more secure and less likely to blow out during use. If you plan to make a lot of roman candles, it is even more efficient to have a long ramming block with several nipples side-by-side so that you can work on five or six candles in parallel.

Figure 3: Using a funnel to load the clay bottom plug.

Figure 4: Ramming the clay with a wooden dowel rod.

Figure 5: A recessed plug formed from the ramming base.

Begin by placing the tube onto the ramming block and ramming a 5/8" thick clay plug. Using a funnel as shown in Figure 3 helps guide the clay into the tube during this process. It is best to ram the plug using one increment of clay, rather than trying to build it up using several increments. A 5/8" ramming rod made from wood, brass or aluminum can be used with a brass hammer as shown in Figure 3.

Return the funnel into the top of the candle and insert 3/8 teaspoon of 2F BP lift into the tube so that it rests on top of the clay plug. This will be the lift charge for the last star that the candle fires.

Next you will add a star on top of the lift charge. The diameter of the star should be slightly smaller than the candle I.D., so that the star can drop easily to the bottom of the tube. Star selection is of your preference and depends on the use of the candle. Chinese candles use round stars, while traditional European candles employ cylindrical shaped pumped stars. If pumped stars are used, the star must be longer than the diameter of the candle in order to prevent it from flipping sideways and getting wedged in the tube during both the loading and firing process. Figure 7 shows both types of stars. A pumped star has more volume and thus will provide a large chunk of burning material, which may yield brighter colors or thicker tails. Round stars must be used for color changing effects, allowing attractive effects such as streamers to color.

Since most candles are designed to be enjoyed one at a time, each shot is usually a different color or effect. A candle that just shoots all one color stars would get boring by itself, but can be effective when a dozen or more of them are bundled together and fired all at once.

A common problem with small candles is the consumption of the star before the lift is ignited to an extent that it reduces the stars flight. To fix this dilemma, place the funnel back into the candle and insert a heaping 1/8 TSP of lift charge on TOP of the star. This will create a flash of fire down to the lift when the burning delay charge reaches the top of the star and will eject the star before it is consumed.

Next add a 1/2 table spoon of delay composition. The actual amount may vary depending on the size of the delay granules, but the rammed finished height should be 3/4" above the star. This delay composition produces a fountain like effect in between shots and provides the necessary fire block between lift charges. Use a 5/8” rammer to ram the delay with 4 to 6 light blows, not swinging the whole arm as when ramming a clay nozzle. You need to ram it hard enough to insure that the delay comp is compressed solidly and seals any gaps along the edges, but not as hard as if you were ramming a rocket or gerb. It is important not to ram too hard or you could crush the lift charge granules or crack the star.

This process is repeated, lift – star – lift - delay, until the intended number of shots has been completed. You will notice that the stars will achieve increasing height as the candle performs. This is a result of the length of the stars “mortar” increasing as each star is shot out. This effect can be compensated for by increasing the lift slightly for each star as you work your way up the candle. Some builders actually build special scoops for each shot, designed to measure out the correct amount of lift to keep all stars firing to the same height.

Figure 6: Loading the BP lift charge increment.

Figure 7: Two types of stars used in roman candles.

Figure 8: Inserting a star after the lift charge is loaded.

This is advisable if you plan to build roman candles for competition, but not necessary for just having fun.

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Roman Candles...

Figure 9: Notching the end of a dowel rod to make the finishing drift.

Figure 10: The notched ramming drift.

Figure 11: Locking in the fuse with the finishing drift.

While a hooked piece of fuse can be inserted into the tube above the delay comp to fuse the candle, a more secure fusing method is to ram the fuse in with the last delay increment, thus locking it in place. To do this, a special notched rammer must be fabricated as shown in Figure 10. Special thanks to Dan Williams for this great tool tip. This drift can be created using a drill press as seen in Figure 9. Clamp a scrap piece of 2x4 lumber onto the drill press table and drill all the way through with a 5/8” bit. Make sure the hole in your table will accept a bit of 5/8” diameter before drilling! Insert the 5/8” dowel stock from the bottom through the hole until flush with the top of the 2x4 material. Do not cut the dowel before drilling as it makes it easier to hold in place while drilling and to remove from the lumber when finished. Using a 3/16" drill bit, adjust the workpiece so that the hole will be drilled right at the edge of the dowel as seen in Figure 9. Lock the table in place and hold on to the dowel below the press table. Drill into the dowel and lumber 2” deep. Remove the dowel from the lumber and cut to length – approximately 5 inches.

After ramming the final increment of delay, insert enough loose delay composition to create a 1/2” of rammed comp and stick a piece of safety fuse to one side and into the loose delay charge. Slide the drift into the tube placing the safety fuse into the void, then ram as before.

Finish the candle by gluing two turns of 30 lb kraft around the top and twist the paper down onto the safety fuse. This nosing will protect the delay from igniting from sparks of adjacent fireworks.

Firing the Candle

A Roman candle should always be lit with caution. It is ironic that roman candles are commonly thought to be safe to fire while holding them in your hand, since they are more prone to malfunction than many other pyrotechnic devices. Any gaps or voids in the delay comp can cause a rapid fire burst of all shots at once, driving the candle out of your hand. The same phenomenon can also cause the candle to explode if the tube wall can not handle the pressure of all shots trying to fire at once. Poorly made candles have also been known to blow out the bottom plug and send flaming balls out the tail end at the same time, which could cause serious injury if held out in front of your body. Hot dross from the burning delay comp can also drip down and burn holes in your shoes, pants and skin. Regardless of what you've seen or what you did as a kid, Roman candles are not devices that can be safely held in your hand during use.

With that said, a way must be found to secure your candle in a vertical position without risk of it tipping over during the display. Shoving candles into the ground can be a chore or can even bend and destroy them. Spent class C tubes or pipes rammed into the

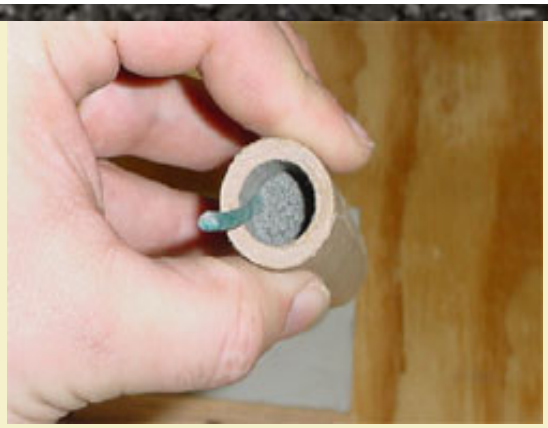

Figure 12: Top view of driven in fuse.

Figure 13: Nosing paper applied.

Figure 14: Attaching a stake for securing the candle during use.

ground work well as holding containers. A 5 gallon bucket full of sand allows the candle to be easily inserted and provides a heavy, stable base as well. Another method is to tape a large wooden skewer to the side of the candle so that it may be easily anchored into the ground. Place the skewer so that the blunt end rests near the top of the candle and the point extends well beyond the bottom, as seen in Figure 14. Wrap a couple of turns of strapping tape around the candle and skewer both at the top and bottom. Note that this does not work in well in frozen ground and is also not stable in overly soft ground.

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Figure 1: Using a hole saw to cut 2" diameter end plugs.

Figure 2: Gluing two 3/4" thick plugs together to form the end plug.

Figure 3: End plug glued in place using wood glue.

Project 2: Large Candle

While the traditional method of candle construction previously described works well for smaller diameter candles, it poses problems with larger diameter candles. As the diameter increases, so does the volume of delay comp required to pad between the stars. This not only increases cost in terms of materials used, but also puts greater demands on the roman candle tube, which must stand up to the continuous burning of delay comp for the duration of the candle without the tube wall burning through. Larger candles also tend to use insert devices such as salutes, crossettes, small shells and other devices that may become damaged by a delay comp burning around the outside of them.

For larger candles, delay composition is not used between shots and timing is done with fuse. Various methods exist, but they all have one concept in common: bulkheading between each shot with a light-weight material to seal against gas leaks and then using some kind of fuse as the timing mechanism.

The candle described here uses one continuous piece of visco type safety fuse to control the timing and ignite each shot, with a fine sawdust bulkhead between shots. The absence of a delay comp allows us to use a much thinner tube wall than would otherwise be required. The tube used here is a 24" long spiral wound tube with a 2" I.D. and a 3/16" wall. Because this candle will be shooting 1-3/4" diameter insert shells as the shots, the tube must be strong enough to handle the lift force. Be sure to test your own tubes by firing a few 1-3/4" shells from them before making this type of candle.

To plug the bottom of this tube, you will need to cut two 2” circles of 3/4” wood and glue them together cross grained to form an end plug. A 2-1/8” hole saw with the drill bit removed from the arbor will produce the appropriate sized wooden plugs, as seen in Figure 1. Apply wood glue to the inside bottom of the tube and insert the wooden plug flush with the bottom. Small finish nails or staples can also be nailed through the tube wall to secure the plug even further. Let the glue dry before proceeding to the next step.

Next you will need to cut a length of safety fuse 6” longer than the candles’ inside length and bend the last inch at a right angle, as seen in Figure 4. Insert the bent end of the fuse into the tube all the way down to the wooden plug. Inserting a notched cardboard disk down over the bent piece of fuse helps to secure the fuse in place and prevent it from getting pulled out of place during assembly. The entire construction of the candle from this point on must be done vertically to avoid shifting the components.

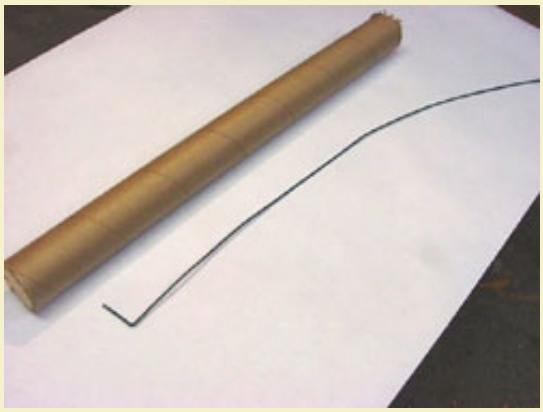

Figure 4: A long length of visco cut a few inches longer than the candle tube.

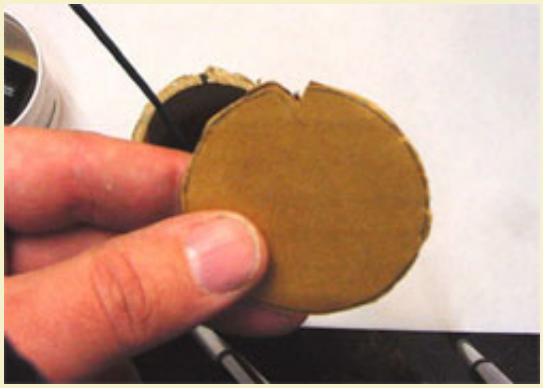

Figure 5: Inserting a notched cardboard disk on top of the visco "hook".

Figure 6: Tube is fused and ready to load.

Figure 7: A 1-3/4" ball shell is loaded above

Pour 1-1/2 tea spoons of 2FA BP for lift into the tube, shaking the tube gently from side to side to level the powder grains. Push the fuse to the side of the tube and drop one 1-3/4” shell into the tube so that the time fuse of the shell rests to the side and contacts the lift powder as seen in the cross sectional diagram on the title page of this article.

After loading the shell, pour in 1/2 cup of sawdust on top of the shell. A finely powdered sawdust is highly recommended for its ability to seal well against gas leaks. Using granular sawdust or chips can cause the first shot to ignite all shots at once, which will likely detonate the candle and throw live shells in all directions.

Insert a wooden tamping stick and consolidate the sawdust down flat making sure to ram the corner of the stick next to the fuse from time to time while tamping. Drop down another 1/2 cup of sawdust and tamp flat as well. Be sure to concentrate around the fuse area to maintain a tight fire block. The sawdust should compress to 4 inches above the lift charge to give the correct delay time. Figure 8 shows the completion of the first shot after the sawdust has been added.

Repeat this process again for each of the remaining three shell shots, placing 1-1/2 teaspoons of 2FA BP for the lift on each one. When pouring the lift down on top of the sawdust delay, lean the tube slightly toward the fused side in order to create a slight buildup of lift around the fuse area.

Once all four shells are loaded, a mine will be added as the first shot in the candle. The mine will create a nice starting effect and give the candle some variety. Note that mines should not be used for effects further down the candle as the mortar length will be to long.

Cut four 2” disks out of corrugated cardboard and run a bead of hot glue on one disk and stack another on top to create the piston for the mine. Snip a small piece out of the side of each disk to allow room for the fuse, as seen in Figure 5.

The mine will use 1-3/4 teaspoons of 2FA BP lift and will create more pressure on the sawdust below it than the other lift charges will. To help protect the last sawdust delay under the mine from this increased back pressure, slide a single cardboard disk into the tube before loading the lift charge for the mine. Align the snip in the disk with the fuse and press it down into the candle firmly on top of the sawdust. It is easiest to press in the disk in level with your hands and then slowly push on the disk with as large of stick that will fit in the tube to avoid flipping the disk. This step may not be necessary, but it doesn't take much time and is a bit of insurance on a device that has a lot of time invested in it already.

Pour in the 1-3/4 teaspoons of 2FA BP lift charge for the mine, followed by the piston disk. If the piston disk fits real tight or you are worried about the stars burning for too long before the lift charge ignites, you can perforate the piston disk as seen in Figure 9. The holes in the piston will allow quicker fire transfer to the lift charge.

Measure out 1/2 cup of the stars of your choice and place them

the lift charge.

Figure 8: Sawdust is firmly packed around the shell to a thickness of 4" above the lift charge.

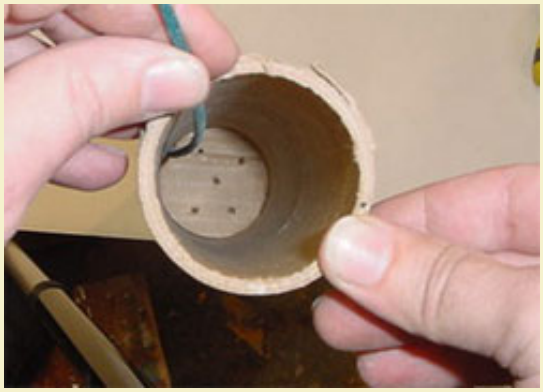

Figure 9: Placing the lift disk over the BP charge on the final mine shot.

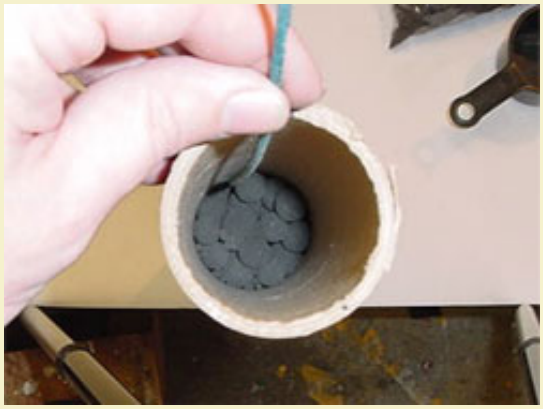

Figure 10: Mine stars placed on top of lift disk.

inside the candle on top of the piston. 3/8” to 1/2" stars are a good size to use depending on burn rate. The stars seen in Figure 10 are 1/2” stars of Slow Gold formula rolled over 1/4” crackle cores. These stars are chosen for their tail effects which make a full mine that appears to be larger than 2”.

Drop in 1/2 teaspoon of 2FA BP on top of the stars and shake down to integrate it into the mine. Place the remaining single cardboard disk into the candle and press down onto the stars, as seen in Figure 11.

The fuse extends up the candle for several more inches which could cause premature ignition on its way down the tube. Protect the stars from sparks by placing 1/4 cup of sawdust on top of the cardboard disk and tamp flat. Bend the fuse over the top and secure to the tube with tape or pasted paper. This last step is an important precaution to insure that the fuse can not be yanked sideways, which could loosen the sawdust around the fuse and create an air gap that would either fire all shots at once or, more likely, detonate the candle.

The candle is finished by gluing a couple protective layers of thin kraft paper over the top as seen in Figure 13.

Firing the Candle

As previously mentioned, Roman candles should not be held in your hand. This is ESPECIALLY true of larger candles such as this one, which would cause serious damage were anything to go wrong. The kickback force of large candles will also blow them right out of your hand were anyone foolish enough to try such a stunt. This candle is best fired by dropping it into a 3" mortar that is buried in the ground, then retiring behind a safe barricade.

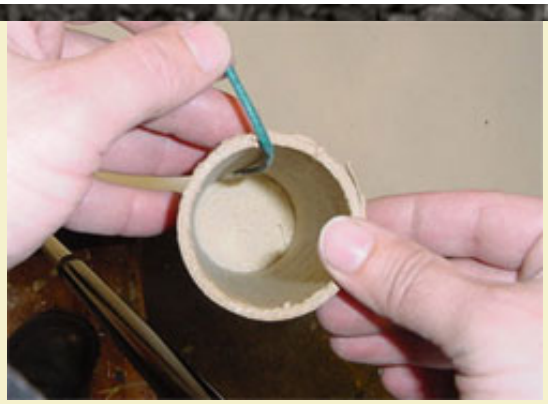

Figure 11: Sawdust packed on top of mine stars.

Figure 12: Securing the visco to the candle.

Figure 13: A protective cover pasted over top the candle.