PASSFIRE.COM

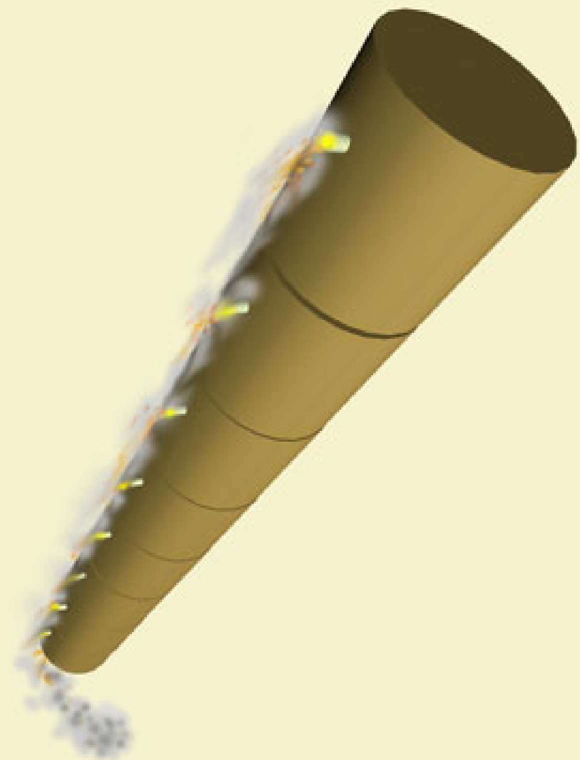
Log Out

Volume 6, Issue 2

Build This...

4" Eight Break Piled Shell

by ***Kyle Kepley***



Summary:

This eight break exhibition shell uses a rarely seen trick to obtain short delays between breaks without the risk of chain reactions from spolette blow-through. While the construction technique is a bit unorthodox, the piled shell method produces a very fault tolerant shell that can survive several different types of failures and still perform with minimal detraction. The shells shown built here were fired in the 2005 PGI competition and took second place in the Best Medium Cylinder Shell category.

Materials:

- (36) 3-3/8" diameter 1/8" thick chipboard disks
- (7) 23" long x (shell height + 3") wide poster board
- (7) 23" long x (shell height + 4") wide 60 lb kraft
- (1) 23" long x (shell height + 7") wide poster board
- (1) 23" long x (shell height + 8") wide 60 lb kraft
- (8) 23" long x cut to size 30 lb paste wrap strips
- (1) 36" long x cut to size 60 lb final paste wrap
- (1) 36" long x cut to size 30 lb outer dry wrap
- (1) 3" tall x 2-1/2" dia. bottom shot w/2 sec delay
- (8) 2" long x 1/4" I.D. x 1/2" O.D. pipette tubes
- (208) 3/4" comets
- (1) 4" long stick of thin black match"

Tools:

- 3-3/8" dia. case former
- hot glue gun
- awl
- thin, sharp knife
- spiking horse
- Maltese shell roller
- 4 strand twine dispenser

- (1) 3-1/2" plywood disk with notch
- 150 g 1/8" rough powder lift (ball milled)

Unmeasured Materials:

7:1 KP rice hulls, Chinese time fuse, flax twine, cotton twine, fine sand, 1/4" rough powder, 2Fg BP, meal prime slurry, wheat paste, white glue, hot glue, tissue paper, 3/4" wood wedges, newspaper, fiber tape, quickmatch leader

4" Eight Break Piled Shell...

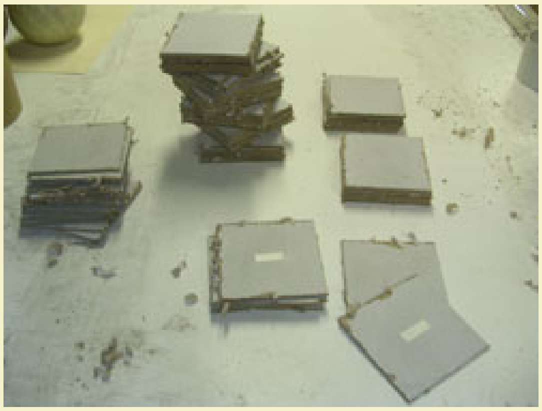


Figure 1: Taping blocks of six 1/8" chipboard squares together with double sided carpet tape.

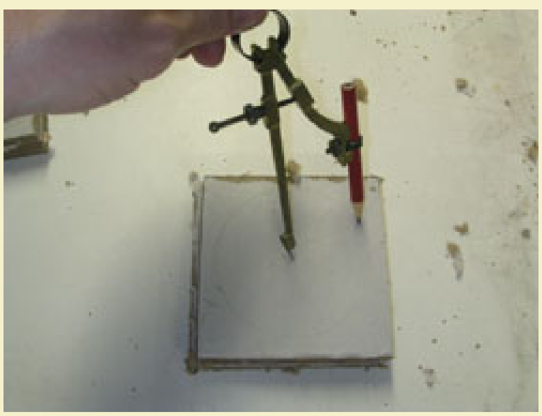


Figure 2: Using a compass to draw a 3-3/8" circle on the top disks.

Introduction

Smaller diameter shells with six or more breaks, also known as "fence post" shells for their long narrow profile, have been an ongoing quest of mine for quite some time. These shells present a unique challenge in that the more breaks you have, the shorter the timing must be between them in order for them all to complete before hitting the ground. The standard practice is to begin breaking the shells almost immediately after the shell leaves the mortar, such that you have breaks going off for the full rise time of the shell as well as the fall time.

There are several aspects that make this type of shell difficult to achieve. The long, narrow body of the shell is more subject to breaking in half during the lift. The long size also makes construction a bit tricky, although the method used here makes it pretty simple. The weight of the shell puts a lot of pressure on the bottom breaks, making flowerpot failures a lot more difficult to prevent. The number one challenge, however, is to achieve the rapid timing between the breaks. Short delays means short spolette charges, which are notoriously difficult to keep from blowing through. An eight break shell would need no more than a 3/8" charge of fast burning BP in the spolette tube, which isn't much to stand up to the large pressure generated inside a shell before it breaks. Thus the most common malfunction in fence post shells is blow through from one break to the next, resulting in chain reactions where several breaks go at once. I've actually had all eight breaks go at the same time in some cases, while other times three or four went as a group.

One way to deal with the blow-through problem is to use weaker break charges in the shells. Anyone who has ever seen Jim Freeman's eight breaking three inch shells at PGI competitions may have noticed that the breaks seem to have less spread than what you would normally expect from a 3" shell. It is very difficult to use a hard-hitting, flash-enhanced break charge in a multi-break that only has 3/8" or less of spolette charge.

I've tried all manner of spolette construction in the quest to find one that can hold up to a hard hitting 4" comet shell, but never came up with a reliable solution. The most common method is to ram an oversized charge and then drill a small diameter hole into the charge to get the proper amount of timing. The best results I have had were from ramming a 3/8" I.D. thin walled recycled kraft tube with a charge that bulged the tube wall, then combining the drilled back technique with a clay bulkhead on the end that passed fire into the next break. The same method used on smaller I.D. spolettes using much stronger tubes had a much larger failure rate. The harder tubes were not able to hold the contents as well as a bulged out recycled tube, which is contrary to the common notion that only rock hard tubes should be used for spolettes.

Figure 3: Cutting six disks at a time with a band saw.

After several years of trying to make an eight break shell with respectable, hard hitting breaks, I decided that the basic design of chained multi-breaks was an unreliable method for doing this. I decided to revert to an alternate construction method known as "piled" multi-breaks. A piled shell is any multi-break where all breaks take fire at the same time when the shell fires from the mortar. The most common piled shell is the "peanut shell," which is two ball shells attached together with their fuses linked together, which take fire from the lift charge. Ball shells are difficult to stack in numbers greater than two breaks however, so you rarely see more than two piled ball shells.

Figure 4: Separating the disks after cutting.

Piled shells solve a lot of problems, although some would consider this method "cheating" since the whole spolette challenge is avoided. Piled shells are very fault tolerant. If a piled breaks in half on the way up, everything still functions without any but the most astute audience member noticing. If one shell fails to take fire, it doesn't break the chain and terminate any further breaks the way a traditional multi-break would. If one break flowerpots during lift, the others will usually survive and perform as expected. A piled shell can also be constructed with the bottom shot located at the top end of the shell relative to how it is loaded into the mortar, thus keeping the most destructive break at the least stressed end of the shell. Traditional multi-breaks require the bottom shot to be at the bottom of the shell chain, thus exposing it to the most lift forces and resulting in destruction of the entire shell (not to mention the mortar) if there is a gas breech. Piled shells also allow you to use extremely short durations between breaks that simply would not be possible with a spolette. The shell described here uses one half second timing between breaks, which would require something like a 3/16" spolette charge!

Figure 5: Rolling the shell cans.

There are some timing limitations to the piled shell method when using commercial timed fuse as the timing mechanism, since the time span from lift until when the last break fires will be dictated by the longest segment of time fuse that can fit sideways in your shell. The eight break described here pretty much pushes this limitation as far as it can go, with a pretty rapid timing between breaks such that the eighth time fuse in the last break actually spans the entire width of the shell! If you were ramming your own side-mounted spolettes, however, you could get around this limitation by just using a slower burning delay composition.

Now, I know some old-school traditionalists are going to pooh-pooh this unorthodox construction method as being a glorified case of "double loading" stand alone shells. But if you want to have eight breaks of hard hitting comet shells fill the sky at a comfortable height in the span of about five seconds to completion, I challenge anyone to pull it off with the traditional chained spolette method!

Construction

This shell consists of eight breaks built using a combination of Maltese, Italian and Oriental shell building techniques. The cans are produced in the Maltese style, which are fast to produce and result in

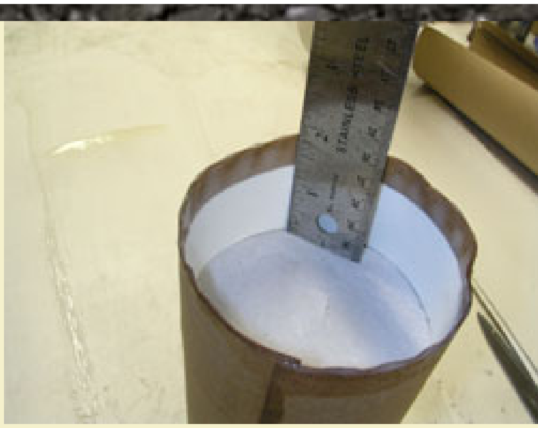


Figure 6: Leaving 1.5" of poster board above the end disk.

Figure 7: Preparing the internal pipettes.

Figure 8: Cross matching the bottom shots with extra long match.

a good break. The shells are also loaded using wedged comets like a Maltese break, while the fusing is piped into the side similar to how Chinese ball shells are made. The spiking is the Italian style, while assembly and lift are in the Maltese style. I guess you could say this shell is pretty multi-cultural!

The pictures shown here actually illustrate two 8-break shells being built side by side, which were fired as a pair in the PGI competition of 2005. So you are really looking at twice as many components as you would actually need to build just one shell.

Making End Disks

When building overly long shells such as this one, the standard shell diameters can result in shells that have difficulty fitting into the mortar. The various breaks never align with great precision, and small alignment offsets can result in irregularities that prevent the overall shell from fitting smoothly into the mortar. This tight fit also results in more stress on the shell when it is fired, especially if an overly long gun is used.

There are two ways to solve this problem: use an oversized mortar or build an undersized shell. Since it is inconvenient to have to drag a custom steel mortar around with you whenever you fire this shell, the undersized shell solution is used. The shell I.D. is reduced by 1/8", which means you will need a 3-3/8" case former and matching end disks to build the shell.

Case formers do not have to be fancy solid wood pins with handles on them, you can use any smooth cylindrical object that is the right diameter. For this shell I used a segment of cardboard mailing tube that happened to be 3-3/8" O.D., then wrapped a few turns of plastic packing tape around the outside in order to protect the cardboard from paste during use.

This shell requires 36 end disks of 3-3/8" diameter, which is an odd-ball size that you might not be able to find at a typical hobby pyro supplier. I opted to cut my own disks from 1/8" thick thermal insulation board commonly sold as 4ft x 8ft sheets in many home supply centers like Home Depot or Lowes. The board is recycled chipboard with a silver foil coating on one side and white paint on the other side.

The board must be cut up into 36 rough squares that are about 4" on a side. If you are using hand tools like a circular saw or jig saw to cut the squares, don't worry about being sloppy with the cuts. The squares are over sized so that you have room for slop.

The squares are then stacked into groups of six as seen in Figure 1. A small piece of double sided carpet tape is used between the squares in order to hold each stack together. Stacking the squares in this way allows you to cut six disks at once, such that you only have to cut out six circles on a band saw instead of thirty six circles. The tape is there to insure that the disks don't slide around while you cut them.

Use a compass to scribe a 3-3/8" circle on the top disk of each pile, as seen in Figure 2. A band saw with a 1/4" wide blade is then used


Figure 9: Holding the match with a retaining tube to keep it centered.


Figure 10: The bottom shot loaded into the last break.


Figure 11: Dusting in the bottom shot with sand.

to cut out the circles six at a time as seen in Figure 3.

Once the disks are all cut, a knife is used to separate them from each other and the strips of carpet tape are pealed off. The process is not quite as bad as you would think, I think I made 72 disks for this project in about one hour. A table saw or panel saw can make short work of cutting the large sheet in to 4" squares, which is probably the most time consuming part if using hand tools.

More...

4" Eight Break Piled Shell...

Figure 12: Placing a layer of rough powder on top of the bottom shot.

Figure 13: Loading two rows of comets on top of the rough powder.

Preparing the Components

Because the shell casings are best loaded while they are still damp after pasting, it is necessary to prepare all the internal components prior to rolling the casings. This includes eight time fuse tubes, a tray full of 7:1 KP on rice hulls for the burst charge, about 50 3/4" x 3/4" wooden wedges, some 1/4" rough powder, a 3" bottom shot made as described here and 208 3/4" comets of your choice. To make the shell exactly as the one built here, you would need 72 mag red comets, 72 mag green comets and 64 silver glitter comets. All comets are primed in a star roller using 40 parts meal powder to 1 part medium flake bright aluminum or something close to that. Priming 3/4" pumped stars in a star roller, preferably the tire type, goes very fast but does leave a lumpy prime that creates slight variations in star size. Since there are only three rows of stars used in each break, the varying heights do not cause much of a problem.

The time fuse will not be inserted into each break until the entire shell is assembled and pasted in. In order to make inserting the fuse easier, an internal pipe is put into place that will accept the time fuse and guide the ignition fire to the center of the shell. These pipes should be 1/4" I.D. and about 1/2" O.D. with a length of 1.5". One end of the pipe is covered with a square of pasted tissue paper so that the burst charge can not migrate into the pipe after the shell is loaded.

It is important that these pipes are pasted or glued with a 50/50 white glue/water mixture when rolling them. A dry rolled tube can cause big jamming problems when a tight fitting time fuse is inserted, and it is difficult although not impossible to fix when it happens.

Making the Cans

The shell casings are made using the wet rolled Maltese method, which is actually faster than dry rolling and pleating in the Italian style. The breaks will contain three rows of 3/4" comets, thus you need to know the height of your comets so that you can produce a casing of the proper height. You can always produce an overly long casing and trim it down later if you like, but it is less work to just get it right to begin with. It is best to produce and prime your comets first, then measure three of them end to end. Add a quarter inch to this measurement and this will be the inside height of your break. Add three more inches to this number and this will be the width of the poster board you need to cut. The width of the kraft strip needs to be equal to the width of the poster board plus an additional half inch. Both the poster board and the kraft strip should be 23 inches long.

The eighth break of the shell will contain a 3" bottom shot in addition


Figure 14: The third row of comets contains the pipette glued to the shell wall.


Figure 15: Loading comets into the single color break shells.


Figure 16: Punching the fuse hole through the shell wall and into the pipette.

to the three rows of comets, so a longer can needs to be rolled for this one. The bottom shot should be completed prior to rolling the 8th break casing. The height of the completed bottom shot is measured and added to the dimensions determined for the other casings.

The cases are formed by first brushing paste onto one side of the 60lb kraft strip, then overlaying the poster board by half as seen in Figure 5. The first turn of poster board is wrapped around the former, then paste is brushed onto the remaining area of poster board. The casing is then rolled up the rest of the way.

An end disk is dropped into one end so that 1-1/4" of poster board extends above it, as seen in Figure 6. If you made disks using the thermal insulation board, the silver side should face downward. A more detailed description of how to close the can be found here. The edges are sliced into tabs with a thin, sharp knife, then the kraft is separated from the poster board. The poster board tabs are folded down, then a second disk is placed on top. The kraft tabs are then folded up over the disk to hold it in place, brushing on extra paste as needed.

Loading the Comets

While the cans can be loaded after they dry, it is actually best to load them right after rolling them while they are still wet. The cans do not need to be fully loaded, only the three rings of comets should be loaded. Comets that are loaded into a damp casing will be firmly locked into place as the casing shrinks around them while it dries. This will secure the rings a lot tighter than is possible by just shimming between the stars with wooden wedges. When using the wet load method, you don't need to even shim the comets very tightly. Just insure that there are no spaces between the comets and let the shrinking paper tighten them down into solid rings.

The eighth break containing the bottom shot is loaded by first inserting the bottom shot into the can and then filling around it with sand as seen in Figure 10 and 11. Note that the bottom shot is first cross-matched with an overly long strand of match, as seen in Figure 8. The match is then bent upwards and a small 3/8" I.D. tube is slipped down over the time fuse in order to keep the match strands pointed upwards. By guiding the extended strands of match up closer to the ignition point of the shell, the probability of ignition failure on the bottom shot is decreased.

The small space around the bottom shot and the shell case is to be filled with sand, as seen in Figure 11. Sand is preferable to sawdust since it is faster to load and it doesn't compress. Bouncing the shell on the table while pouring the sand will help to settle it down around the bottom shot. The sand is only filled just to the top of the bottom shot, then a layer of rough powder is added as seen in Figure 12. The three rings of comets are now loaded on top of the rough powder just as they are for the other seven breaks.

More...

Figure 17: All the breaks are loaded, dried and ready for break charge.

Figure 18: Close-up of shell loaded with 7:1 KP on rice hull break charge.

Mail Passfire.com

4" Eight Break Piled Shell...

Figure 19: Slicing the tabs for closing the shells.

Figure 20: Tabs are glued and folded down over the end disk.

The shell shown here uses two rings of color comets with a third ring of silver flitter comets. The flitter comets add a nice coconut tree effect inside a ring of bright color comets, which alternate between red and green for each break. Thus you will need to mark the effect on the outside of each casing so that you can keep track of them as the shell progresses. All the comets look the same, so you need to be careful about labeling what is actually loaded into each shell.

When loading the third ring of comets, the fuse pipe will take the place of one of the comets. A ring of hot glue is run around the end of the tube so that it can be fastened to the shell wall. This ensures that the pipe will not fall out of place or get pushed into the shell when the time fuse is inserted. Figure 14 shows a fuse pipe in place, with the tissue covered end facing the inside of the shell. The tube should rest on top of the second ring of comets and be firmly wedged in with the third ring of comets.

Once the hot glue dries on the fuse pipe, an awl is used to punch a hole through the outside of the shell casing so that it enters the fuse pipe. This hole will be expanded later, but for now it is necessary to punch the hole so that the entry point for the fuse can be known later after the shell is closed and pasted.

Figure 17 shows all the cans loaded for two eight break shells. The cans are now set aside to dry before proceeding further.

If you loaded the cans while they were still damp after rolling them, you will find that the comets are firmly locked in place after the cans dry. In fact, it is not uncommon to actually see the comet pattern from the outside of the casing as the paper shrinks in tight around them-a sure sign that you will get nice round ring patterns.

The shells are loaded with KP coated rice hulls, with a coating of 7 parts KP per one part hulls. The hulls are the typical American flake type, which pack more densely than the Chinese whole-hull type (similar to puffed rice). The entire void remaining inside the shells are filled with this 7:1 charge, which will break the shells hard and round but still insure good ignition of the comets.

Closing and Spiking

Once the break is loaded into all the shells, they are closed as seen in Figures 19 through 21. A disk is dropped in on top of the loaded contents, then the overhanging casing is sliced up into tabs and folded down as seen in Figure 20. White glue is applied to the tabs and then a second end disk is applied over the end.


Figure 21: A second end disk is placed over the tabs.


Figure 22: Starting the spiking twine with knot located next to fuse hole.


Figure 23: Off-center spiking used to spike the shell.

Because these shells do not have a time fuse sticking out one end, there is no convenient place to tie off the spiking twine. The twine must be tied around the middle of the case as seen in Figure 22. It helps to position the knot close to the fuse hole so that it is easier to find after the shells have been pasted in, since the knot will be visible but the holes will not be. For the shells shown here, the knot was consistently located to the right of the hole on every break. This way all you have to do is find the knot and then punch a hole to the left of it to relocate your time fuse hole after the shells are pasted in.

The twine used to spike these shells is the domestic six strand natural flax twine sold by PyroSupplies. This is similar to the Italian flax twine traditionally used on canister shells and is ideal for 4" and 5" canister shells. The spiking pattern used here is not real dense, only eight verticals and five or six horizontal wraps are required. The off-center spiking pattern is used in order to keep the ends as flat as possible. Keeping the ends flat by avoiding string pile-ups will reduce the gap between the breaks when the shell is assembled, which in turn reduces the amount of paper that has to be stuffed between the gaps and also reduces the chances of the shell breaking into pieces when fired. Interestingly, due to the design of this shell, it will still function correctly even if it does break into one or more pieces on the way up!

Pasting

Figure 24 shows all the shells spiked and ready for pasting. These will be pasted in with two turns of recycled 40 lb kraft paper. The recycled kraft actually produces a better gas-tight seal around the shell compared with virgin kraft, as it lays down better and seems to shrink tighter. This paste wrap does not play any role in confinement of the break, it is only there to fire proof the shell. The ends of the shell are pasted by tearing tabs in the overhanging paper and folding them down, as seen in Figure 26. The torn edges actually produce a better gas seal compared with cut edges, and it is quite easy to tear the recycled paper by hand. Since there is no time fuse to paste around, this process goes pretty fast.

Since you don't have a time fuse to mark with a tape flag to indicate the shell contents, you must be careful to sort your pasted shells according to effect while they are drying. Otherwise you will lose track of the effects in each shell. Once the paste wrap is dry, which doesn't take long in a drying box, you should mark each shell to indicate the contents.

Once the paste wraps are dry, it is time to punch holes where the time fuse outlets are. The thin 40 lb kraft should allow you to see the spiking twine pattern underneath, and hopefully you can locate the knots that serve as your hole markers. Once you locate the knot, poke around with an awl to find the time fuse hole, then use a pencil tip or reamer to clear the hole to it's full size, as seen in Figure 27.

More...

Figure 24: Two sets of shells ready for pasting.

Figure 25: Pasting two layers of 30lb recycled kraft onto each break.

Figure 26: Ends are pasted by folding over tabs torn in the overhanging paper.

Figure 27: Re-punching the fuse holes after the pasted paper dries.

4" Eight Break Piled Shell...

Figure 28: Aligning the shells on a Maltese Shell Roller.

Figure 29: Starting the spiking twine at one end.

Assembling the Breaks

At this point we basically have eight independent shells, each of which could be fused and fired on its own. In fact, when this shell is fired, you still have eight independent shells, each with its own time fuse that ignites when the shell lifts and each performing independent of the other shells. We are merely binding all the shells together so that they can be loaded and fired as a single unit. This is actually not all that different from "double loading" eight shells on top of each other. For those not familiar with the practice known as "double loading," this is a technique where a second shell is loaded on top of the first shell loaded into the mortar, except the second shell has its lift bag and leader removed. The lift from the bottom shell also lifts the second shell while simultaneously igniting its exposed time fuse. Normally this is only done with smaller diameter ball shells during a finale in order to increase the shell count without adding additional mortars or e-matches.

In order to align all eight shells and allow them to be easily rotated while stringing them together, the Maltese Shell Roller is a must-have tool. The shell roller is shown clamped to a table in Figure 28, with all eight shells aligned end to end. The shells are positioned so that all of the time fuse holes align in a straight line. You should be able to intersect all the time fuse holes with a straight line when they are positioned correctly.

Since all the shells must be able to rotate as a single group while spiking them together, it is necessary to glue them end to end with hot glue. Apply a liberal amount of hot glue to the center of one shell and then press it together with the next one in line while keeping the fuse holes properly aligned. Normally this step would not be necessary with a traditional multi-break shell, since the spolettes would help keep them together. Because these shells don't have spolettes, they are a little more difficult to work with and the shell itself is more prone to breaking in half during lift. However, the actual performance of the shell is not affected even when it breaks into one or more pieces, so we are not overly concerned with preventing that type of failure.

The shells are held together with a single set of eight or nine strands of strong twine. The twine being used here is the Imported 7 strand linen flax twine from PyroSupplies. You can also use double strands or more verticals if you don't feel your twine is strong enough or if you are overly concerned about the shell breaking into pieces during lift. Keep in mind though that the more verticals you use, the harder it is going to be to ram the newspaper into the gaps between each shell.


Figure 30: Leveraging the twine spool against the shell to cinch the twine tight.


Figure 31: Completed vertical spiking for holding the breaks together.


Figure 32: Ramming damply pasted newspaper between the breaks.

Again, since there are not spolettes for tie-off points, the twine must be started by tying it around the shell at one end, as seen in Figure 30. It is important to pull the twine as tightly as possible when spiking the shells together. One technique for cinching the string tight is to hold the roll of twine against the shell when cornering the ends and then torque it tight as seen in Figure 30.

Once eight verticals have been secured, you will make a ninth pass back down to the end of the shell where you initially tied off the twine. It is a bit tricky to tie off the twine at this point without letting some slack creep in. I find it easiest to work the twine under the horizontal tie-off wrap and secure it with a few half hitch knots.

Figure 31 shows the shells after they have been spiked together. You may notice that once the first shell in the group bursts, all the twine would then be unsecured and loose. You would think that the remainder of the unspent breaks would then break apart, but this does not tend to happen. The paper that is pasted over the twine tends to effectively keep the tension on the twine, as does the horizontal windings that are wound around the joints to take up the slack in the vertical wraps. Thus it is more efficient and just as effective to spike multi-breaks as a single group when building smaller diameter shells such as this, rather than spiking the breaks successively as each one is added. I use this same technique on four break six inch shells and have yet to have one come apart.

Next is the task of filling in the voids between each break with newspaper. This is an important step in preventing the shell from being able to flex during handling and from breaking in pieces when fired. The newspaper is lightly coated with wheat paste prior to ramming it in place with a thin wedge shaped stick, as seen in Figure 32. The paste helps the paper to ram in more densely and also solidify upon drying so that the paper is less apt to compress and allow the shell to bend. I use one page of typical news print to produce crumpled up pieces that are dampened by coating you hand with paste and then brushing it onto the paper by pulling down the length of it. It will take about two pages to fill each void, depending on how much of a gap you have. The paper must be worked under the spiking twine as you rotate the shell, ramming as you go.

The last step in assembling the breaks together is to tightly wrap several turns of cotton twine around the joints in order to cinch the vertical twine as tight as possible. In a normal multi-break shell this step would also add an additional fire block to prevent lift gas from getting between the breaks and setting the shell off out of sequence. For our piled shell this type of failure can not occur.

The cotton twine is applied in bands of four strands, which feed off of four separate spools. I find that the most useful tool for doing this is to make PVC spools of twine and then slip them onto the rotating jig for winding black-match twine that is described here. This jig will rotate as you pull from the four spools at once, which allows it to auto-position itself for minimal binding The jig is placed on the floor and the four strands are passed through a sheet of newspaper as seen in Figure 34. You can then step on the paper with one foot to control the resistance of the twine as you roll it onto the shell. This setup allows you to really crank the twine onto the shell with a lot of tension, giving you a very solidly spiked shell that bends very little even before the paste wrap is applied.

The twine is started with a clove hitch around the first junction at one end of the shell, then progressed from one junction to the next. Use as many turns as it takes to build the twine up almost flush with the outside of the shell casing. If you didn't ram enough newspaper, this can sometimes result in a lot of twine being used between breaks. Figure 35 shows how the twine is moved from one junction to the next. After the last junction is stringed, finish with another clove hitch the same way you started.

Pasting

This shell is pasted in with two turns of 60lb recycled kraft. The only purpose of this paste layer is to protect the string from the lift fire and help hold the breaks together. This weak grade of kraft does not add any integrity to the break strength of the casing.

A single sheet of kraft is laid out and pasted on both sides, but is not broken in the way you normally would when making canister shells. The paste is just smeared on by hand and then the shell is rolled up, as seen in Figure 36. Because this shell is so long, it can be difficult to roll the pasted paper on as tight as it needs to be. You should be able to see the string pattern through the paper after each turn, squeezing it down with your hands as you roll to insure a tight fit on the shell.

The ends of the shell are pasted over by tearing the overhanging paper into tabs as seen in Figure 37. The tabs are then folded down over the end and smoothed out. The shell should be stood on its end while it dries, preferably with air blowing across it in order to speed up the drying time.

More...

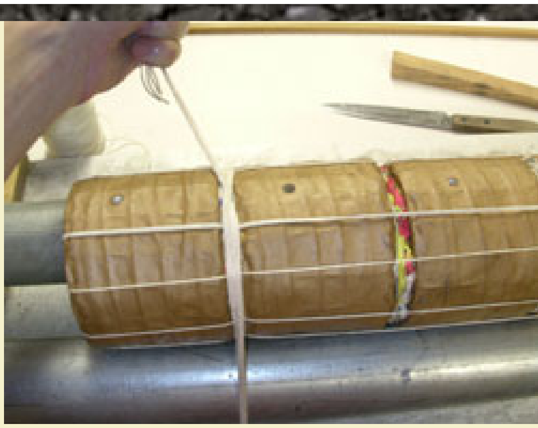


Figure 33: Starting the horizontal twine wraps with a clove hitch around the last break.

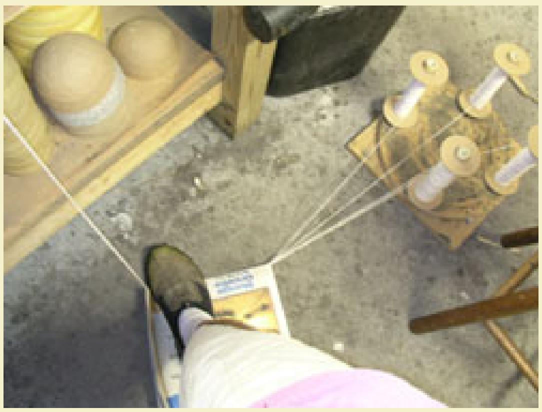


Figure 34: The spool arrangement with foot pressure for tension.

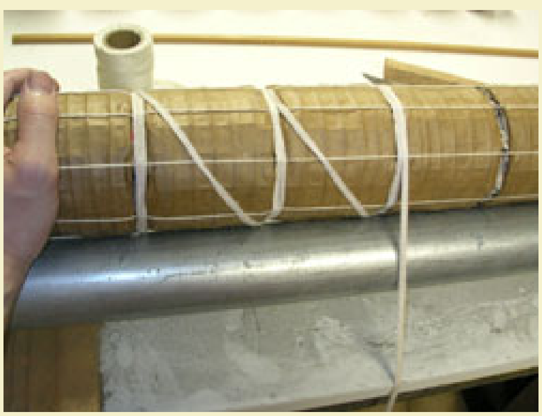


Figure 35: Tightly wrapping many turns of twine around the joint gaps.


Figure 36: Finished shell being pasted in.


Figure 37: Pasting over the ends of the shell.

Mail Passfire.com

4" Eight Break Piled Shell...

Figure 38: Increasing series of time fuses cut for each break.

Figure 39: Charging the pipette with 2Fg black powder.

Fusing

Now for something a little different. Normally you would be lifting and leadering your shell at this point, but you haven't even fused it yet! The first thing you need to do after the paste wrap completely dries is to locate all the fuse holes and open them back up. This can be a little tricky, since the paper is thicker this time and you don't have any markers to look for. What you have to do is poke around very lightly with an awl or other sharp object until you find one of the holes. Once you find one hole, it is easy to find the rest because they are all in a straight line (or at least they should be). Care must be taken when searching with the awl though, since the shell casing is actually quite thin and if you punch a hole through it you will create a breach in the casing that will cause it to burst when the shell lifts. When the awl hits the hole, it will go through very easily. If you meet any pressure at all, move on to another spot.

Next you need to cut eight pieces of time fuse that correspond to the break timing that you want. These will look something like Figure 38, with an increasingly longer piece of fuse for each break. Of course you can do anything you want, you have a lot of control over timing with this method. If you wanted to have two shells going off at the same time for each break, you could cut four sets of fuse pairs. You can cut fuses that have only a very slight increase in length in order to have a very rapid series of breaks. You are somewhat limited if you want delays longer than a half second when using standard Chinese time fuse, however. For example, if you wanted a second between each break, which means you would really have to send this shell up high for it to complete before hitting the ground, then your last time fuse would need to burn for at least nine seconds. But since the diameter of the shell is only 3.5" minus 3/4" for the comet at the other side, you would not have the space to contain the 4" segment of time fuse required to burn for 9 seconds. Only about 1/4" of the time fuse can protrude outside the casing due to space constraints, so the longest fuse you could use is about 3" long.

If you were fuse the shell with home-made spolettes, then you could ram them with a slower burning powder and get around this timing limitation. When using the spolette method you could simply charge the pipette that you glued to the inside of the shell and skip the hole time fuse insertion step. All you would need to do is open up the holes and fuse them with some black match leading to the outside of the shell. You could even ram the spolettes with a silver gerb composition and get a very interesting rising effect!

The time fuses cut for this shell start at 1-1/4" long and go to 3" long in 1/4" increments. Thus the eight fuses measure 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75 and 3". This gives about a half second delay between


Figure 40: Fuses inserted into the pipettes.

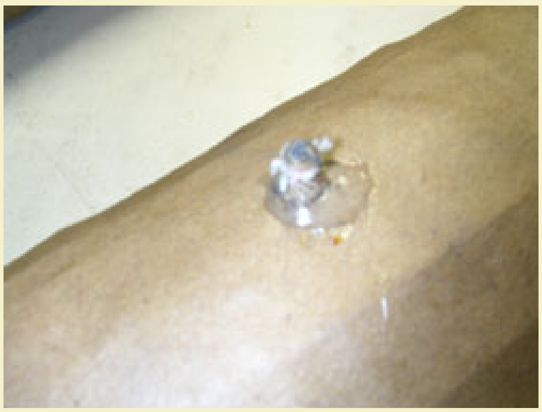


Figure 41: Hot glue sealing the base of the time fuse.


Figure 42: Priming the time fuse.

breaks, with the first break firing at around two seconds. Note that one end of the time fuses is cut at a 45 degree angle, which is the end that is inserted into the shell. Since you can not cross-match the inside end of the fuse, it is cut at an angle in order to expose a greater surface area of the powder core.

Before each time fuse is inserted into its corresponding hole, a small amount of fine grain black powder is charged into the hole first as seen in Figure 39. This helps insure that there is something that takes fire easily in contact with the end of the time fuse, which will also create a strong burst of fire out the end of the pipette. You want to have a burst of fire out the end of the pipette instead of the little poof of sparks you get at the end of a time fuse when it burns through. Note that this method of fusing, a central pipe filled with a small BP charge into which a tight fitting piece of time fuse is inserted after the shell is completed, is the standard practice for fusing most Chinese shells. As long as you cap your pipettes with a tissue barrier so that the powder grains will always be contained right at the tip of the time fuse, then this method is just as reliable as cross matching the time fuse, and actually gives better fire transfer than cross matching.

Figure 40 shows all eight fuses in place, with only 1/4" or less of the fuse sticking above the shell wall. The last couple of fuses will actually be longer than the internal pipette, so they will break through the paper barrier and thus do not require the BP charge. They will be in contact with the burst charge however, so ignition should not be an issue.

Next you need to apply hot glue around the base of each time fuse, which is important for preventing the lift gas from leaking in around the time fuse and setting the breaks off in the gun. Make certain that this glue bead is complete and that there are no air gaps.

The time fuse ends are now heavily primed by first making a slight cut into the end of the fuse with a razor to expose more of the powder core, then applying a thick prime slurry on top as seen in Figure 42. The heavy prime insures that all the fuses will take fire from either the passfire running down the side of the shell or, failing that, from the lift charge when the shell fires. Once the prime slurry is applied, the additional step of dusting the wet prime with a fine grain black powder or some corning dust will add an even greater degree of ignitability. Figure 43 shows to completed shells with primed and dusted fuses in place.

Lifting

This shell is lifted using the Maltese method, which is described here. The charge used is 150g of 1/8" rough powder, but could vary depending on how strong your home-made meal is. I use home-made spruce charcoal and ball-mill my meal to a very fine state before making the rough powder, so the lift is quite strong.

Careful observation will reveal that the lift charge has actually been attached to what would normally be considered the top of the shell, which is the first break. The break with the bottom shot, which is the last one to fire in the sequence, has been located at the top of the shell. This upside down arrangement is a safety precaution that is


Figure 43: Primed and dusted fuse tips on two shells.


Figure 44: Assembling the lift components.


Figure 45: Lift components held in place with fiber tape.

done to keep the bottom shot in the least stressful and least destructive location. Since the bottom shot will destroy the mortar and generate dangerous steel shrapnel if it flower pots, the worst location for it would be right above the lift charge. With normal multi-break construction this is unavoidable, but with the side fused shell it can be fired from either end. By putting the bottom shot on top of the shell, it will be far less likely to ever experience a gas leak or side rupture, and in the event that the bottom shot did go off before the shell lifted, such as in the case of a passfire failure, then the flash detonation would occur safely outside the mortar (assuming your shell sticks out the top of the mortar, which it should.)

Two wads of rolled newspaper are used for the sabot, allowing for more cushioning against the lift forces. The passfire entry hole in the lift charge can is positioned slightly to one side of the chain of time fuses, as seen in Figure 44. The passfire tube will run right down along the side of the primed fuse tips. I used a paper punch to punch a small hole through the leader pipe right next to each time fuse. This may not be necessary however and could reduce the propagation speed of the piped match by causing a loss of the internal pressure. It is likely that the primed fuses would all take fire even without the holes punched in the side of the leader.

Figure 46 shows one large piece of 30lb kraft paper being used to roll three turns of paper around the shell. Unlike normal multi-breaks, the side fused method requires the whole shell to be covered in paper so that the primed fuses are protected from sparks. The paper also helps contain the gases when the fuse prime ignites, which helps propagate the fire between the primed spots and insures complete ignition.

The paper is tied around the top of the shell using two separate tie points, as seen in Figure 47. Only a minimal amount of fuse leader is required, since the shell will likely be sticking out from the mortar when it is loaded.

This shell can be fired from a standard size 4" steel mortar and still lift to a proper height. In fact, this shell is designed to be fired from a standard 4" mortar. If an overly long mortar is used that allows the entire shell to fit inside with nothing sticking out the top, then your risk of flower potting will greatly increase. Don't be afraid to have a couple feet of shell sticking out above the top of the mortar, it is actually less stressful for your shell to be fired this way. If you must use a long mortar, you should reduce the amount of lift charge accordingly. The longer the mortar, the less lift you need. Of course many times you don't know in advance how long a mortar will be when firing shells such as this at competitions, so it is best to design for a standard size 4" mortar and not worry about it. Otherwise it is advised that you test your shell from your own custom mortar and then bring that mortar with you to competition in order to eliminate this very important variable.

Figure 46: Rolling the outer wrap around the shell.

Figure 47: Finished shells ready to fire!

Mail Passfire.com