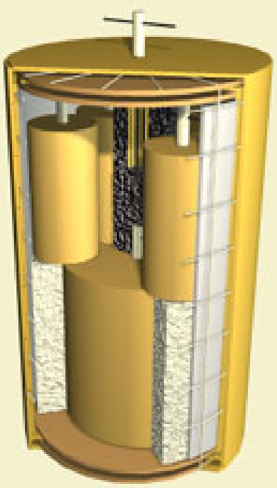
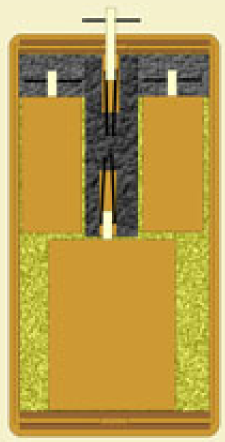
Build This...

5" Rondelle w/Bottom Shot





Summary:

The Rondelle is a classic canister shell that bursts with a ring of timed reports which fire sequentially in a clockwise or counter clockwise progression. The effect is usually terminated with a final bottom shot when the ring has completed.

This article describes how to build a simple rondelle using time fuse as the timing mechanism. Various methods of constructing bottom shots are also covered, with a detailed description showing the easiest and most economical method.

Materials:

- (3) strips 24" long x 11-1/2" wide 70lb virgin kraft, grain short (case)
- (1) 23" long x 7-1/2" wide chipboard, grain short (liner)
- (3) 24" long x 13-1/2" wide strips 70lb virgin kraft, grain short (paste wrap)
- (1) 36" long x 18-1/4" strip of 30lb kraft, grain short (outer wrap)
- (4) 4-1/2" kraft or chipboard end disks, 1/8" thick
- (7) 1-1/4" O.D. x 1" I.D. x 2-1/2" long slaute tubes
- (7) 5" wide x 8-1/2" long 70lb kraft)
- (7) 4-1/2" x 8-1/2" long 30 lb recycled kraft
- (1) 5-1/2" wide x 17" long 60 lb recycled kraft
- (1) 5" wide x 18" long poster board, grain short
- (1) 3" wide x 28" long poster board, grain short
- (4) 2-1/2" chipboard end disks, 1/8" thick

Tools:

- 4-1/2" dia. case former
- Rubber mallet
- 1" OD dowel with 5/16" hole in one end
- Cross match punch
- 7/32" drill bit
- Hot glue gun
- 1/2" x 12" long tamping rod
- 1/8" x 6" long tamping rod
- 2-1/2" case former
- Anvil cutters
- Scissors

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5" Rondelle w/Bottom Shot...

Figure 1: Ready to roll a bottom shot.

Figure 2: Pasting the inner case.

Figure 3: Centering the inner case when rolling the outer case.

Introduction

This shell reminds me of a T-shirt I once saw at a fireworks convention which contained the following shell performance description: "Salutes to reports to bottom shot." The shirt was of course poking fun at how many names we have given to things that simply go "BANG!" The rondelle fits into this class of shell known as "timed reports," which contain nothing but sound producing effects. Since there are no visual effects other than the flashes of white light, the shell is suitable for display in both daylight and at night. In fact, the puffs of white smoke left behind actually make daylight viewing more entertaining, as anyone who has witnessed the barrage of such shells that occur at dusk during any PGI convention can attest. The puffs of rolling white smoke create a static image of the shells performance suspended in space, drifting off with the wind like credits at the end of a movie.

Although this shell contains nothing more than flash powder and black powder, the effect is not a trivial one to achieve. A successful rondelle requires the builder to demonstrate three things: 1) the ability to produce well-made salutes that do not detonate when the shell breaks, 2) the ability to produce accurate and evenly paced timings and 3) the ability to keep track of multiple timed devices during construction so that they are properly loaded. This last one may seem like a no-brainer, but I can't tell you how many times I've seen a "rondelle" where the reports randomly jumped around in the ring rather than follow the required circular progression.

Because this shell does demonstrate the essential skills mentioned above, it is a good one to include in your lineup when competing in shell competitions. The shell described here uses a 3" bottom shot, which keeps it within the accepted guidelines for anyone wishing to use it as a PGI competition entry. The shell seen in the pictures was actually fired as part of my Level 3 shell competition for PGI in 2005, which took 1st place.

Bottom Shot Construction

A defining feature of bottom shots is a very strong case wall, which is necessary both to produce a loud report as well as withstand the high compression forces during lift. Since bottom shots are usually located at the bottom of multi-break shells with lots of weight above them, they are subjected to more compression during lift than other shell components are. A flimsy bottom shot such as one made from a thin-wall spiral wound tube or, even worse- using a standard shell casing simply filled with flash, runs the risk of crumpling under pressure, which can cause the outer shell casing to rupture and cause a detonation that usually destroys the mortar and sometimes even nearby mortars. Canister shells with bottom shots produce the most

Figure 4: Rolling the final outer layer.

Figure 5: End disk inserted while still on the case former.

Figure 6: Pleating the first set of tabs.

hazardous failures when they blow in the gun, usually sending heavy chunks of shredded metal pipe flying through the air for substantial distances. So it is very important from a safety standpoint to produce a good quality bottom shot. The bottom shot should be well protected against gas leaks so that it can survive a shell flower-potting in the mortar without going off. A well made bottom shot should eject from the mortar if the carrier shell explodes before making it out, such that it detonates high in the air instead of in the mortar.

The most common method for making bottom shots is to use a very thick walled spiral wound tube, with a minimum wall thickness of at least 3/4" for a 3" or 4" bottom shot. The bigger the diameter gets, the thicker the case wall needs to be. When a thick enough wall can not be found, you can use multiple thin-walled tubes nested inside of each other, such that the O.D. of the inner tube equals the I.D. of the outer tube. Because such thick tubes are hard to cut, they are typically ordered precut to the desired size.

The commercial thick-walled spiral salute cores will produce a very strong and loud bottom shot. The problem, however, is often trying to obtain the desired tubes. Hobbyist suppliers typically do not carry this type of tube, so they have to be ordered in large minimum orders from industrial suppliers. Some companies that specialize in paper products for the fireworks industry will also require a BATF permit to even order these things. This often leaves the hobbyist with no choice but to roll his own bottom shots.

Using many strips of chipboard cut with the grain running in the short direction, it is possible to roll your own convolute bottom shot cores. The process of cutting all the strips and rolling them up to a thickness of 1" or more can be a tedious one, but it does produce good bottom shot cores.

The fastest method of producing good quality bottom shots I have found is the Maltese method using pasted poster board, which is the method described here. The pasted poster board is considerably stronger than chipboard, so the case thickness can be much thinner while producing the same results. Using 5 turns of poster board on a 2-1/2" case former, I have had as much as ten pounds of shell weight sitting on top of these without ever having any problems. The shots can be made louder by rolling even more layers of poster board or by spiking the shot with a denser spacing of stronger twine.

Making the Bottom Shot

Traditional Maltese bottom shots in this size usually employ four turns of poster board. Because it can be difficult to get the end tabs to lay down when they are four sheets thick, I have altered the design a bit so that the case is made from two layers-- a thick inner layer and a thinner outer layer. The tabs are formed on the outer layer, which is only two layers thick so that they can be folded down easier. The inner layer can be made as thick as you want, with loudness increasing with the more layers you use.

To roll the bottom shot casing shown in Figures 1 through 9, you will need three strips of paper. The first is a 28" long strip of poster board with a width equal to the height of the bottom shot you wish to make (3 inches in this case). This will produce about three turns around a

Figure 7: Second end disk placed over tabs.

Figure 8: Pleating down the second set of tabs.

Figure 9: Dried bottom shot can ready to load.

Figure 10: Chipboard liner in place.

2-1/2" case former. If you have 2-5/8" end disks available, which are somewhat common, then a better bottom shot can be constructed by rolling enough turns of the 3" wide poster board to produce a 2-5/8" diameter case on the former. This way the end disks can be supported by this inner part of the casing and the chipboard liner is not required. If you wanted to really go nuts you could use 3-1/2" disks and roll a 1/2" thick inner core, producing a larger bottom shot that would still fit inside our 5" shell.

The first turn is dry-wrapped around the case former, then the remainder of the strip is coated with paste as seen in Figure 2. The pasted strip is then quickly rolled up onto the former and any paste that oozed out onto the former is wiped up.

The second piece of paper is an 18" long strip of poster board that is two inches longer than the desired bottom shot height, or 5" wide in this case. This piece of poster board is overlaid onto a strip of 60 pound recycled kraft that is a half inch wider and of the same length, as seen in Figure 1. Both sheets are pasted fully on one side. Note that the extra half inch of kraft extends beyond the poster board on the edge facing away from the case former.

The case rolled from the first sheet is now centered on the next two sheets as seen in Figure 3, then the next two sheets are rolled up onto the case former together as seen in Figure 4.

Next you need to slide the finished case up to the edge of the case former and drop an end disk in place as seen in Figure 5. Note that the edge of the inner casing should be flush with the top of the end disk. If you are using the alternate method where the end disks are larger than the case former diameter, then the disk would actually sit on top of the inner case and it would not be visible in Figure 5.

The end of the case is closed by using a thin, sharp knife to cut tabs all the way around the circumference, which must be done quickly before the paste softens u the paper and makes it more difficult to cut. Once the tabs are cut, the kraft paper is pealed back away from the poster board, as seen in Figure 6. Paste is then brushed onto the end disk the white tabs are folded down. Paste is brushed onto the tabs as needed to get them to stick down as you go.

The second end disk placed on top of the folded tabs, pasted on top and then held down by folding over the kraft tabs as seen in Figure 8. Paste is again used as needed to help the tabs stick down.

At this point you should have a bottom shot can that looks like Figure 9. This is now set aside to completely dry before proceeding further. If the case is not allowed to fully dry before it is spiked with string, then the spiking string will lose its tension due to shrinkage that occurs to the case as it dries.

Note: a better way of building this is to insert the disks containing the time fuse first instead of the bottom disk as shown here. The reason is that it is easier to pack sawdust around the fused end before loading the flash rather than having to insert the fused end through the sawdust as seen in Figure 14.

Figure 11: Filled with 70/30 flash.

Figure 12: Tamping sawdust above the flash.

Figure 13: Fused disk ready to close the can.

Figure 14: Care must be taken not to knock

Once the case is dry, you are ready to load. If your end disks are the same size as the case former used to roll the can, you will need to insert a chipboard liner into the case as seen in Figure 10. The purpose of this liner is to support the top disk so that it doesn't get pressed down into the easily compressible flash powder. The liner should be cut so that the top falls about 1/8" below the edge of the inner casing, which can be seen in Figure 10.

The bottom of the casing is first charged with a layer of sawdust, tamped down to a thickness of about 1/4" to 1/2". Sawdust is used both below and above the flash charge as a preventive measure against ignition from gas leaks when the container shell bursts.

Next the case is charged nearly to the top with flash powder. The flash shown here is 70 parts potassium perchlorate mixed with 30 parts American dark aluminum (also known as 809), with a handful of 10 mesh titanium flakes thrown in for spark effects. The flash was mixed by first screening the perchlorate through a 60 mesh screen to remove all the lumps. The aluminum and perchlorate were then mixed together on a sheet of newspaper by picking up the corners and shifting the pile back and forth until no more white pockets of concentrated perchlorate could be seen. The titanium flakes were then added and "diapered" in using the same technique to evenly distribute them into the mix.

No sulfur is needed for flash to take fire form a cross matched piece of time fuse. If your salutes don't ignite, the problem is your black match and not the ignitability of the flash. Adding antimony to flash is also an unnecessary increase in friction sensitivity with no discernable gain. If you want a louder bottom shot, use German dark or Indian black head aluminum, roll a thicker case or spike with more twine or stronger twine. Those are the variables that make a difference, not spiking your flash with hazardous additives.

Once filled with flash, the case is now topped off with another layer of sawdust. Because we are closing with the fused disk here, an object equal to the diameter of the piped fuse must be inserted into the center of the flash while tamping the sawdust, as seen in Figure 12. This preserves a pass-through hole for the fuse to contact the flash. Just pushing the fuse through the sawdust in hopes that it will reach the flash will result in the pipe getting plugged up with sawdust, making a fire block that will very likely prevent the salute from igniting. This added hassle is why I suggest making the can with the fused disk first so that it can be loaded upside down and closed with the bottom disk.

Figure 13 shows the fused disk used to close the bottom shot. This is the standard construction I use for all canister shells-a piece of cross matched time fuse with a dry-rolled pipe made from three turns of kraft around a 3/8" rolling rod. The pipe can also be stuffed with additional segments of black match if you are concerned about having enough fire transfer to ignite the flash. Generally a pipette is used to create an ignition point at the center of a shell rather than at one end, which results in faster flamer propagation to all parts of the shell. In the case of a flash filled salute this is really not important, but the pipe is needed to get past the sawdust barrier so it still has a function here.

any sawdust into the fuse hole.

Figure 15: Slicing the tabs on the top side.

Figure 16: Painting white glue over top tabs.

Figure 17: Hot glue sealed around time fuse base.

The shell is now closed similar to how you closed the bottom end, only this time the tabs are dry so you can not separate the kraft from the poster board. The entire tab is folded down and brushed with white glue as seen in Figure 16. A bead of hot glue is run around the base of the time fuse before inserting the top disk, then time fuse base is again sealed with another bead of hot glue once the top disk is in place.

Since bottom shots don't have stars and burst symmetry is not a concern, you can spike them with cotton twine if you choose. When using cotton twine, saturating the twine either before or after it has been applied will go a long way toward increasing its holding strength. I prefer to use the most absolute strongest twine I can find, which happens to be the imported 8 strand linen flax twine sold by Pyrosupplies.com. You can never have too much spiking twine wrapped around a bottom shot, so consider Figure 18 to be somewhat of a minimum. The more you use, the louder it will be.

The bottom shot is completed with a paste wrap of 2 turns 30 pound recycled kraft paper. The recycled kraft is preferable to virgin kraft when pasting in shell inserts, as it lays flatter, shrinks tighter and thus produces a better gas-tight seal. Be sure that the paste wrap surrounds and makes a cone around the base of the time fuse, which is the most leak-prone area.

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Figure 18: Spiked with 8 ply linen twine.

Figure 19: Pasted bottom shot is dried and ready for cross matching.

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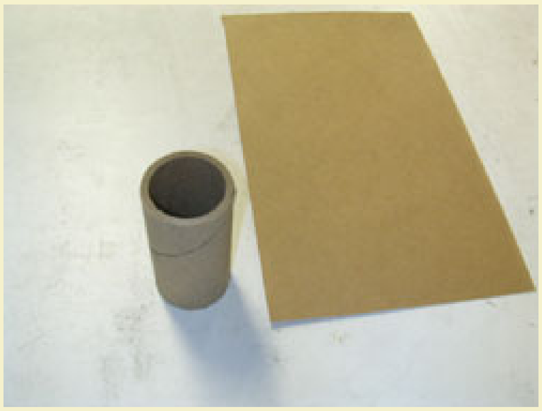

Figure 20: Salute core with outer wrap.

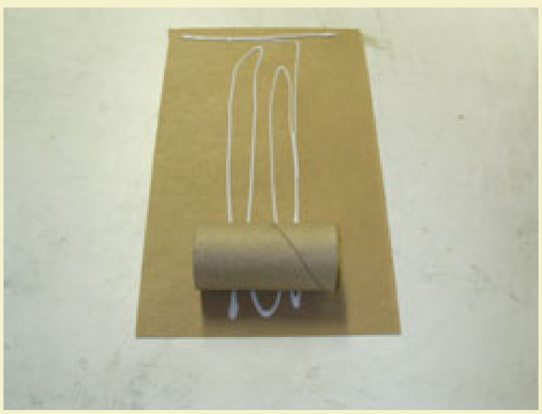

Figure 21: Rolling the outer wrap.

Figure 22: Tools for punching the fuse hole.

Making Timed Salutes

There are various ways to make small salutes for use in canister shells. The method shown here is about as simple as you can get without resorting to plastic insert shells. Basically all you do is roll two turns of 70 lb kraft around a thick inner tube and tri-fold the ends shut like when making pupadelle shells.

The core used for these salutes should be pretty thick in order to get a nice loud report. The ones used here have a 1/8" thick wall, which is about the minimum you would want. The tube measures 2-1/2" long with a 1" I.D. and 1-1/4" O.D. This is the biggest diameter tube you can use while still being able to fit seven of the completed salutes into the shell. You can use a bigger core of course, but then you will only have six reports in your ring. You can also roll your own cores from chipboard or even pasted poster board if you wanted, with the latter giving the strongest casing.

Figure 21 shows two turns of 70 lb kraft being rolled onto the core. The glue running the length of the paper is not really necessary, I just use it to help keep the core from sliding around when folding over the ends.

Figures 28 through 30 show how to make the tri-fold over the end of the tube, in case you don't already know how to do this common fold by now. I prefer to apply white glue between the folds so that the resulting end cap is hard and stays flat after it dries.

Some builders will argue that you can't get good timing on shell inserts without using hand rammed spolettes. However, it has been the experience of myself and others that very good timing can be obtained from standard Chinese time fuse as long as you accurately control the spacing between the cross-match points and use a good quality black match to cross-match the fuse with. Spolettes are both time consuming to make and unwieldy to install in small reports such as these, so time fuse is the logical choice.

The time fuse can be installed either through the side of the report or through one of the ends. I prefer installing the fuse in the end because you don't have to actually drill through the casing to do it, it allows packing sawdust around the fuse inside the casing and it makes spiking and pasting the reports easier. The only time side fusing is really needed is when you have to stack several rows of salutes on top of each other and you want to keep the shell height to a minimum.

In order to punch the time fuse hole through the triangle fold, you


Figure 23: Punching the fuse hole.


Figure 24: Thread case onto time fuse coil before cross-matching.


Figure 25: Cutting time fuse to proper size.

need to make a special dowel rod that has a 5/16" hold drilled through one end, as seen in Figure 22. The dowel rod should equal the I.D. of your salute core, which is 1" in this case. The case is slipped onto the rod and a metal center punch is hit with a rubber mallet to punch the hole, as seen in Figure 23.

Next a long length of time fuse is threaded through the hole and cross matched after pulling it through, which will look like Figure 24. At this point you will need to mark the point where the second cross-match hole will be punched later. The timing will be different on each report, and the lengths will vary depending on how fast you want your rondelle to progress. The timings I used for this shell are shown in the table below. I find that faster paced progressions make the circular motion more noticeable.

Time Fuse Lengths

Component	Timing Length
Main Shell	1-1/4"
Report #1	3/4"
Report #2	7/8"
Report #3	1"
Report #4	1-1/8"
Report #5	1-1/4"
Report #6	1-3/8"
Report #7	1-1/2"
Bottom Shot	2"

After marking the time fuse, it is pulled back through the case until the cross match prevents it from pulling any further. The fuse is then clipped off 1/4" above the punch mark you previously made. Anvil cutters are used for this task in order to prevent the sheering action that scissor type cutters would produce (Figure 25). It is more efficient to prepare all seven reports up to this point before loading them. Be sure to mark each time fuse with a number indicating when it is to fire in the sequence (ie- 1, 2, 3). This is best done by folding a piece of masking tape over the end and writing the number on it.

Once the reports are fused, the next step is to ram some sawdust in around the time fuse, as seen in Figure 26. This precautionary measure produces an additional barrier to gas leaks that can occur when the container shell bursts. If even one salute detonates when the shell bursts, it will set off all other salutes including the bottom shot, resulting in one large detonation that destroys everything in the shell. So any extra work that helps keep this from happening is worth the extra time it may take.

The salute is charged to the top of the core with flash and then topped off with sawdust once again, similar to how the bottom shot was constructed. The salute is closed with another tri-fold as seen in Figure 28 through 30.

The salutes are then spiked with the strongest twine you can find (once again the PyroSupplies 8 ply linen twine was used here). Start by running a bead of hot melt glue around the base of the time fuse. When the glue sets a little, start by tying off on the time fuse with a clove hitch, then run at least six verticals and eight horizontal wraps as seen in Figure 31. As with the bottom shot, the more spiking you use the louder it will be. However, too much spiking may make the

Figure 26: Tamping sawdust around time fuse.

Figure 27: Sawdust pressed above flash charge.

Figure 28: First fold of triangle fold.

Figure 29: Second fold of triangle fold.

salutes oversized so that you can't fit all seven of them in your shell, so you will need to do some trial and error based on the thickness of your string and the diameter of your salute cores.

After the salutes are spiked, they are finished with a paste wrap of two turns of recycled 30 lb kraft paper. Be sure to pile the paper up around the base of the time fuse to help prevent gas leaks in this vulnerable area.

Loading the Bottom Shot

There are two several methods for building a shell with a bottom shot. One traditional method involves making the bottom shot O.D. equal to end disk diameter of the shell being built, such as 4-1/2" for a 5" shell. The shell casing is then rolled around the completed bottom shot instead of using a case former, which locks the bottom shot good and tight into the bottom of the shell casing. There is no need to use sawdust or sand to pack around the bottom shot since it is built right into the shell.

The advantage to rolling the shell casing around the bottom shot is faster construction time. So if you had many shells to make, then this would be the method to use. However, there are several disadvantages to using this method which make it unattractive for most hobbyist applications. For one thing, it forces you to use a bottom shot equal to the shell diameter, which can be quite larger than you may wish to use in many cases. I personally can not hear the difference between a 4" bottom shot and a 5" one, so why waste the extra flash powder unless you gain something from it? In the case of some competition rules such as those used by PGI, using this method of bottom shot construction would result in bottom shots that are too large to be permitted by the size restrictions for certain categories. You have no choice but to make the bottom shot diameter equal to the shell diameter, there is no flexibility with this method.

Another problem with using this method is that the completed shell has a larger diameter than it should, since the bottom shot will have a larger diameter than the standard case former of the same size. In many cases this added size is enough to cause problems with the shell fitting into the mortar, especially HDPE mortars. Often the shell must be pushed into the mortar, leaving no blow-by clearance and thus subjecting the shell to more pressure than it or the mortar may be able to withstand when fired. If building multi-break shells, this oversized bottom break will also not align flush with the other breaks which are rolled on a standard size case former. This results in a seam that is not flush between the last break and the rest of the shell, which will in turn leave a big air gap at the seam when you paste in the shell.

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Figure 30: Completed third fold of triangle fold.

Figure 31: All salutes spiked and numbered.

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5" Rondelle w/Bottom Shot...

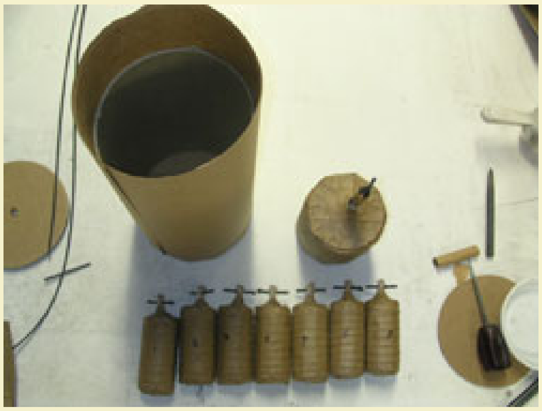

Figure 32: Shell case with components ready to load. Note the sequence numbers have been written on the reports.

Figure 33: Retainer sleeve on the long cross-match of the bottom shot.

There is a way to fix the above mentioned problem if you really want to use this method for building multi-break shells with a bottom shot. You must produce a bottom shot using an undersized case former with undersized end disks so that the completed bottom shot will have an outside diameter equal to the standard case former size for the shell being built. So for our 5" shell example, you would need about a 4-3/8" case former with matching disks, both of which you would likely have to make yourself. Then of course you would have to have a similar set of undersized formers and disks for each size of shell you intend to build using this method.

Another way to get around the size problem is to build the bottom shot the next size down from your shell, such as a 4" bottom shot for a 5" shell, and then roll chipboard or newspaper around the bottom shot until it is 4-1/2" in diameter. Once built up to the correct O.D., you can then roll the shell casing on it. This is a hybrid approach that is sort of a cross between rolling directly on the bottom shot and dusting it into the bottom of a case rolled on a case former. It becomes troublesome when the difference between the bottom shot diameter and the shell diameter are more than an inch however.

The method of construction used for this project is known as "dusting in" the bottom shot. With this method, the case is rolled on a former as usual and a bottom shot that is smaller than the shell diameter is placed into the bottom and packed in with sawdust, as seen in Figure 34.

The bottom shot is first cross matched with an extra long piece of black match, thus increasing its probability of taking fire. A small section of match pipe can be cut and used as a sleeve to keep the long strands out of the way when loading the shell, as seen in Figure 33.

Once the case is rolled and the end disk pleated into place, two turns of chipboard measuring 7-1/2" tall are inserted into the case. The bottom shot is first loaded down into the bottom of the case so that it is centered, then sawdust is poured around it and tamped down with a long dowel rod as seen in Figure 34. The sawdust will compress a considerable amount, so it takes several fills before it reaches the top of the bottom shot.

Loading the Shell

Once the bottom shot is tightly dusted into the shell, it is covered with a thin layer of rough powder, as seen in Figure 35. This will give you a solid, level bedding on which the timed reports are loaded onto. The reports shown in this project were very tight fitting, and all seven

Figure 34: Tamping sawdust tightly around the bottom shot.

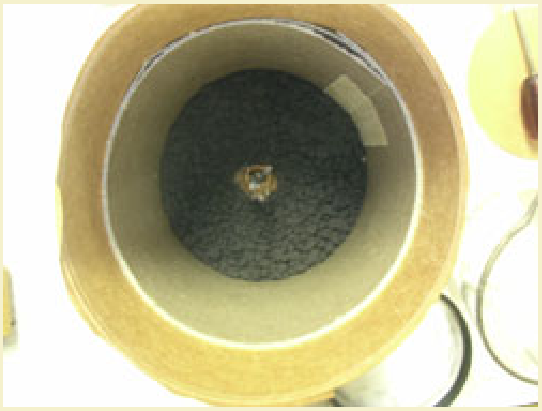

Figure 35: Covering the top of the bottom shot with rough powder.

Figure 36: Reports loaded tightly in to a ring.

of them just barely fit into the shell. Because the reports fit so tightly, there was no need to dust them in. The only purpose of ramming sawdust between the reports and the shell wall is to lock them into a solid ring. If the 7th report requires quite a bit of effort to cram into the shell, they will be tight enough to produce a good break without the need for sawdust. Otherwise you will need to tightly tamp sawdust between the reports if they sit loosely in the shell.

Important: since you went through all the trouble of correctly numbering the reports in the sequence that they will fire, be SURE to load them into the shell in the correct order. Line them up on your table in numerical order and insert them one after the other in a clockwise progression. If you get even just one of them in the wrong place, you no longer will have a rondelle.

The empty space behind the reports was filled with 1/8" rough powder, which is ball milled meal powder pushed through a 1/8" screen as described here. Because ball milled meal powder made with a good charcoal like willow or spruce is quite strong, I chose to fill the central break cavity with the 1/8" rough powder as well. If your own rough powder doesn't have enough kick, you will want to fill the central break cavity with commercial or home made 3FA black powder.

Once the break charge is loaded level with the top of the reports, the remaining space is filled with standard 1/4" rough powder, as seen in Figure 38. An end disk with the time fuse and pipette hot glued in place is pushed through the rough powder to close the shell. It helps to bounce the shell on a table while working the piped time fuse down into it, otherwise it is difficult to get the disk to seat all the way down onto the chipboard liner.

Completing the Shell

The remainder of this article is a review of good canister shell building practices for those who haven't read the 4" Color Break introduction to canister shell building. For those who already know how to finish the job, you get to leave class early.

Now, there is a quick-n-dirty school of thought that finds it satisfactory to simply fold the overhanging paper down onto the disk all at once, slap the second disk on and call it a day. No pleating, no white glue- just crumpled down and held with four strips of masking tape if not spiked right away. Why is this bad? Because what goes together easily also comes apart easily, and closing a shell like this will create a very weak containment of forces pushing against both ends of the disk. When a properly built canister shell breaks, both end disks should remain intact, with the paper still sandwiched between them but sheared clean off around the edges. When slapping a shell together using this slop method, your chances of getting a hose break greatly increase, and is almost guaranteed if you are using cotton twine to spike the shell with.

Sometimes a hose break looks like a nice break if you are looking at it from the right perspective, which is why some people are fooled into thinking this method works. Having inspected the fallen remains of many shells built like this, I can assure you that it doesn't. The only way you can really get away with slop construction is to break the


Figure 37: Filling all open spaces with fast burning 1/8" rough powder.

shell hard with a flash bag or whistle mix booster, which we are not doing here. While a dense color break can hide defective burst patterns depending on burst orientation, a ring of inserts such as the shell built here is much more revealing. It is important that a rondelle shell produce a very clean ring, thus it is important not to cut corners when building this shell.

After closing with the time fuse disk, glue is applied to the top of the disk as seen in Figure 39. Each layer of paper is then pleated down in the pattern shown in Figure 40, with a new application of glue applied between each layer. Not only does this result in a much cleaner and tighter compression of the paper between the two disks, it insures that the paper can not pull out and allow the disks and shell contents to be jettisoned form the end like a sky mine.


Figure 38: Leveling the space above the reports with 1/4" rough powder.

Before applying the second disk, a bead of hot glue is run around the base of the time fuse. It is important to apply white glue to the top and apply the second disk quickly before the hot glue dries (Figure 41), otherwise the dried glue can prevent the disk from seating all the way down. The purpose of this glue is to provide a secondary fire block in case some lift gases make it past the outer seal. It's a very unlikely scenario, but then so is a piece of foam debris taking out the space shuttle. The idea is to take every precaution.

The shell is now spiked with 18 verticals of high quality flax twine. Do not be tempted to use cotton twine. I know it's cheap, I know it's easy to find and I know it's worthless for spiking a shell if you want good break symmetry. The twine used here is the "Domestic Six Strand Natural Flax Twine" sold by pyrosupplies.com, which is the perfect strength for 5" canister shells. The vertical spiking is only a few turns where the bottom shot is located, then about five turns around the area where the salutes are.


Figure 39: Using white glue when pleating over the end disk.

Finally for pasting in the shell you want 4 or 5 turns of a good 60 to 70 pound virgin kraft paper. Figure 43 shows the tan color typical of a high quality paper once it has been saturated with paste. A good kraft paper will not tear easily even when it is wet, which is nice except for when it comes time to tear the overhanging paper to pleat the ends, as seen in Figure 44. While you can use scissors to cut the tabs, tearing the paper by hand actually results in feathered edges that lay down better. Both ways will work, but tearing has the slight advantage for producing the most gas-tight seal possible.

If you can not seem to get the tabs to tear in a straight line, then chances are that you rolled the paper with the grain in the wrong direction. Paper tears easiest with the grain, and the grain should be running from end to end of your shell.

Some builders will fold the tabs over as-is without separating them, while others will separate them out and lay them down for each layer of paper. The latter method results in the best prevention of gas leaks, since folding them all at once can result in wrinkles or pockets of air that lead directly to the shell inside. A good compromise between quality and speed of construction is to separate the tabs into two layers, folding half of them down the first time around (Figure 45) and then folding the rest the second time around.


Figure 40: Sealing around the time fuse with hot glue.

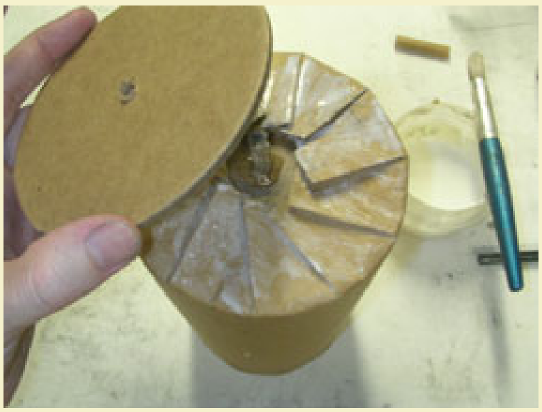
Figure 41: Applying the second end disk.


Figure 42: Spiked with high quality flax twine.

To avoid an overly large hump of paper at the center of the shell, I'll sometimes tear some paper off the ends of the tabs to make them shorter, as seen in Figure 45. A trick to avoid having to do this is to use progressively shorter strips of paper when rolling the casing, as seen in Figure 43. The first strip is the full length required to cover both ends. The width of the second strip is about an inch less than the first, then the width of the third strip is two inches less than the first. This way the tabs get shorter and shorter the farther from the inside you get, resulting in less pileup in the middle and thus less time required for all the pasted paper to completely dry out.

Figure 43: Pasting in with 4 or 5 turns of 70 lb virgin kraft.

Figure 44: Tearing the tabs by hand.

Figure 45: Folding the tabs down in two separate layers.

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