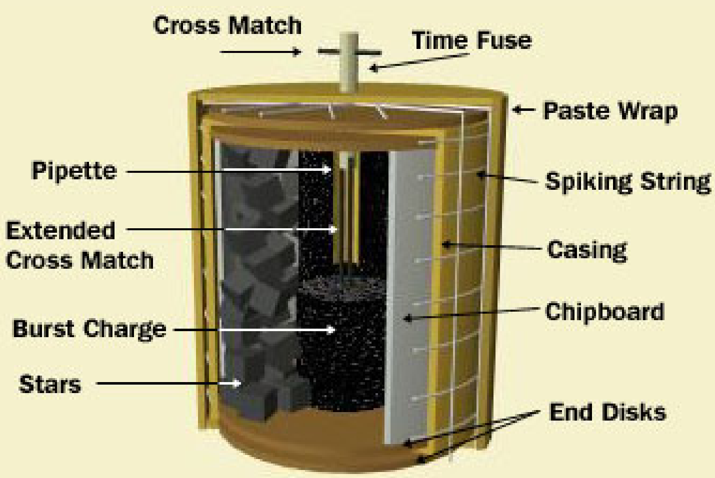
Build This...

4" Color Break Canister Shell



Materials:
(2) 6-3/4" x 24" strips of 70lb virgin kraft, grain short (case)
(1) 3-1/2" x 22" chipboard, grain short (liner)
(2) 7-3/4" x 24" strips of 70lb virgin kraft, grain short (paste wrap)
(1) 11" x 24" strip of 30lb kraft, grain short (outer wrap)
(1) 5" x 8" sheet of tissue paper (burst wrap)
(4) 3-1/2" kraft or chipboard end disks, 1/8" thick
(1) 1-3/4" piece of time fuse
(1) 3/8" ID x 1-3/4" long pipette (2-3 turns of 70lb kraft)
(1) 3-3/4" of 4 strand cross match
(1) 1" piece of 4 strand cross match
(1) 15" piece of 8 strand black match
(1) 30" quickmatch leader
(1) 1.5 oz (42g) 2FA lift charge

3/8" stars, flax twine, 2FA black powder, white glue or wood glue, masking tape

Tools:
Rubber mallet, 3-1/2" Dia case former, 1-1/4" OD dowel or pipe, cross match punch, hot glue gun, 7/32" drill bit, scissors, anvil cutters.

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December, 2001 Issue

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Learn the basics of canister shell construction.

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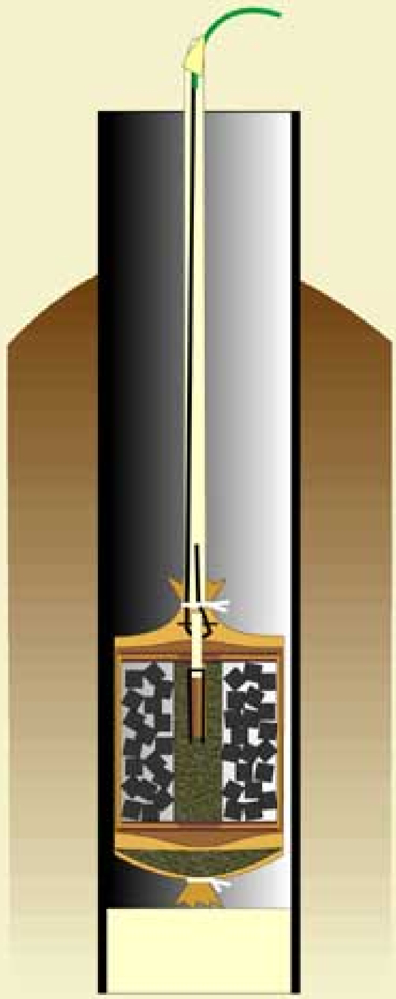
4" Color Break Canister Shell



Introduction:
This article describes one method for constructing a four inch canister shell, which is a good starting point for anyone new to canister shell construction. The method presented here is very similar to the traditional Italian methods as presented in Traditional Cylinder Shell Construction by A. Fulcanelli in Pyrotechnica IX. There are perhaps as many variations for making canister shells as there are people making them, but many key construction principles are common between them.

The canister shell has several advantages and disadvantages when compared to the spherical style shells developed in Asia. The canister shape is such that it maximizes the volume of display material that can be carried for a given diameter. This cylindrical shape is ideal for holding smaller cylindrical inserts such as whistles, serpents, salutes and even smaller shells. The flat ends of this type of shell also make it possible to stack them on top of each other to form longer shells containing multiple breaks, something that can not be easily done with spherical shells.

Spherical shells, however, are naturally stronger and ideally suited for symmetrically round breaks. While a round shell is constructed simply using pasted paper, the canister shell involves a more complex arrangement of paper, thick chipboard disks and a tight wrapping of twine.

The flat bottom of a canister shell must be able to withstand the immense pressure applied against it when fired from a mortar. Since there is less blow-by of lift gasses around a canister shell when leaving the mortar compared with a round shell, the pressure on the shell bottom is even greater. Due to this increased stress during lifting, canister shells must have as much structural integrity as possible. The shell contents must be packed tightly with no voids. Failure to produce a solidly filled canister can result in the shell compressing from the force of the lift and the weight of the shell, causing the sides to split open and spew the burning contents out of the mortar like a mine instead of a shell (a failure known as a "flowerpot").

The casing of the shell must be air-tight so that hot gasses do not enter into the casing during lift, also causing it to flowerpot. The gases generated from burning black powder are just as capable as any spark when it comes to igniting surrounding material. These gases can leak in through cracks around inadequately pasted edges or around the entry point of the time fuse. The time fuse is usually located on top of the shell to keep it out of the high pressure zone and reduce the risk of it blowing through and causing a flowerpot. Bottom fusing canister shells (placing the time fuse on the lift side of the shell and allowing the lift to light it), while quicker from an assembly standpoint, is not recommended for shells over three inches diameter.

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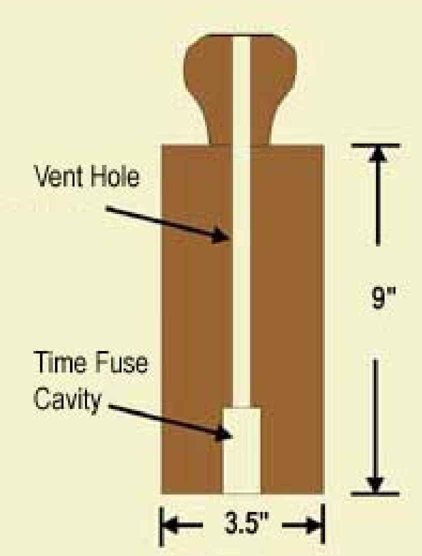

Figure 1: Typical case former.

Forming the Case:
The first tool you will need to obtain for making a canister shell is a cylindrical case former that is 1/2 inch smaller in diameter than the mortar diameter the shell is to be fired from. In this case, you will need a former that is 3-1/2 inches diameter and about 9 inches long, as shown in Figure 1. The case former depicted here was turned on a wood lathe from maple, then a center hole of 1/2 inch diameter was bored all the way through the former. The purpose of this hole is to prevent a vacuum from forming when the case is removed from the former. The vent hole was enlarged to 3/4 inch for a distance of about 2 inches into the bottom of the former to easily accommodate a piped time fuse or spolette. The optional handle was turned such that there is a large flat surface on top, which helps balance the former when resting on its handle during the end disk pleating process.

Getting a suitable former is often the first obstacle faced by new shell builders, and there are many creative options other than having one turned on a lathe. For instance, a segment of HDPE mortar pipe used for 3 inch shells can be used as the case former. The only disadvantage to this is the lack of a solid end for pleating over the end disk, but this shell size is small enough that you can get away with it.

If you do not have 3 inch HDPE laying around, you can also take a segment of 3 inch PVC and build it up to the proper diameter by rolling paper around it. When enough paper is rolled to bring the O.D. up to 3-1/2 inches, a single turn of clear packing tape can be wrapped around it to provide a smooth surface so the case will slide off easily. One could even try and center a smaller PVC pipe inside and fill around it with plaster of paris or some type of masonry patching compound in order to produce a solid end to the former. The diameter of the center hole needs only be large enough to accept the largest diameter time fuse or spolette you ever plan to use, with extra room allowed for ease of insertion.

Once you have your former, you are ready to start rolling cases. Prepare two strips of 70 lb kraft paper that measure 6-3/4" x 24" long, with the grain running parallel to the shorter distance (grain short). All the paper strips used in building this shell will be grain short, which not only allows the paper to roll easier in the case of chipboard, but also provides a greater resistance to buckling when forces are applied against the ends of the shell, such as during lift. The grain of paper is usually not easily visible, but can be determined by folding or rolling the paper parallel to both the length and width of the strip. The direction that folds or rolls easier is perpendicular to the direction that the grain is running. If you are trying to roll chipboard and it starts to wrinkle or creases appear, then you are rolling against the grain. Grain can be harder to detect as the paper gets thinner, but should still be easy to find with 70 lb. kraft.

The reader must be aware that there are many kinds of kraft paper on the market, and while many of them can be made to work with canister shells, the ideal grade is known as virgin kraft. Virgin kraft can be identified by a lighter tan color with very few speckles of tell-tale recycling evidence. The true test, however, is to get a piece wet and observe how it resists tearing. A good piece of virgin kraft should be able to be soaked and crumpled into a ball, then flattened back out without falling apart. The desire for this characteristic becomes apparent during the pasting process. Virgin kraft is most often sold in sheets rather than rolls, but can occasionally be found in rolls too.

Having cut your two strips grain short, proceed to roll them around the case former while using a piece of masking tape to hold the last turn down. When multiple strips are used to form the case, such as in this example, simply interleave the next strip slightly with the one before it and continue rolling. The general rule is one turn of paper for each inch of shell diameter, thus this case will have about 4 turns of paper. The case should be able to slip off the former when complete. If the case tends to get stuck, try rolling it with a few inches overhanging the end it is to be removed from.

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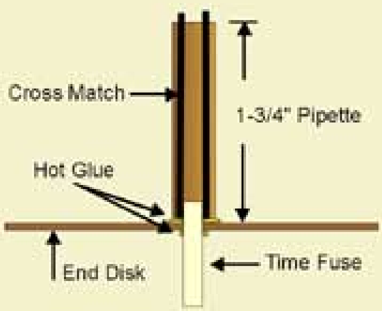

Figure 2: Time fuse assembly details.


Figure 3: Inserting the fused end disk.


Figure 4: Pleating over the end disk.

Fusing the End Disk:
After the case has been rolled, an end disk containing the time fuse is placed on the end of the former with the edges of the rolled case extending beyond the former as shown in Figure 3. The paper should overhang such that it comes fairly close to the time fuse when folded over, but does not hit the time fuse or its surrounding glue.

To prepare the end disk and time fuse as shown in Figure 2, first drill a 7/32 inch diameter hole in the center of a chipboard disk. The disk should be the same diameter as the former, 1/8 inch thick and made of either chipboard or kraft. The kraft disks are stronger, but either type will work here. Disks can be purchased with 1/4 inch holes already punched in them, but a snugger fit around the time fuse can be produced by drilling your own hole and making it slightly smaller than 1/4 inch. This helps reduce the chances of gas leaks or getting blown in if used for multi-break shells.

The time fuse used here is the chinese type which burns approximately 2.2 seconds per inch. A 1-3/4 inch piece will be center punched 1/4 inches from each end, so that the actual length of fuse used for the timing is 1-1/4 inches. This will give a delay time of almost 3 seconds for the shell to reach its break height. If you have Bicford or Japanese time fuse you would rather use, then use a stop watch to time a 10 inch segment of it and calculate its burn rate. The burn rate will then dictate the length of fuse required to give 3 seconds of delay.'s b

Mark a line 1/4 inch from each end of the time fuse, then use an awl to punch a hole through one of the marks. The hole will receive a piece of cross match that is about 3-3/4" long. This 4-strand black powder type fuse should be about 3/32" in diameter and coated both externally and internally with powder to achieve a reliable flame transfer to the piece of time fuse. The other hole can be punched now, or it can be punched after the shell has been pasted and dried. If it is punched now, a piece of masking tape should be pinched around the fuse prior to pasting the shell so that paste does not enter into the hole.

With the cross match centered through the time fuse, insert the time fuse into the hole previously drilled into the end disk. Adjust the time fuse so that the cross match is about 1/4 inch from touching the disk, leaving ample amount of time fuse protruding from the other side. Using a hot glue gun, apply a bead of glue around the base of the time fuse on the side not containing the cross match.

While the glue hardens, roll 2-3 turns of 70 lb kraft around a 3/8 inch rod to produce a thin walled tube that is 1-3/4 inches long. This "pipette" will be used to guide the cross match into the center of the shell so that the burst charge takes fire from the center point rather than at the top of the shell where the time fuse enters. The fire propagation will progress faster when propagating in two directions instead of one, helping to break the shell at the center point instead of from one end.

Fold the two ends of the extended cross match up and slip the pipette over them, sliding it down until it almost touches the end disk. Place another bead of hot glue around the base of the time fuse and sink the pipette into it before it dries. The resulting assembly should look like Figure 2.

Once the hot glue has dried and is stable, insert the fused disk onto the end of the rammer as shown in Figure 3. This method of shell construction is known as the "upside down" technique, since the shell will be loaded in the upside down orientation and closed with the bottom disk. An alternate method involves placing the bottom disk on first, then closing with the fused disk after the shell is loaded. This author finds it more difficult to insert the fuse assembly through the rough powder and burst charge of a tightly packed shell as compared to simply loading it upside down and finishing with a plain disk.

The paper extending beyond the bottom of the disk must now be pleated over the disk using white glue as shown in Figure 4. Each layer of paper should be pleated individually, such that there are four layers of pleated paper stacked on top of each other. Once the last layer is pleated, a rubber mallet is used to tamp down the paper and get them as flat as possible.

At this point the case is slipped off the former and inverted for loading. A small block of 2x4 with a 1/2 inch hole bored through the center makes a good stand for the case while loading it.

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Figure 5: Chipboard liner in place.

Figure 6: Filling stars around the canulle.

Figure 7: Stars and burst charge loaded.

Loading the Shell:
Before the contents of the shell are loaded, a liner consisting of two turns of .01"-.02" caliper chipboard is inserted. The chipboard may be purchased in sheets from some print shops, or even salvaged from scrap cereal boxes. Poster board paper may also be used for the liner, although three turns may be required. The purpose of the liner is to provide a seating for the end disks and add further resistance to crushing forces upon firing the shell. The strip should be 3-1/2" by 22" long, grain short. Smaller strips may be taped together end-to-end if a 22" strip is not available. The chipboard is inserted by loosely rolling it up so that it may be dropped into the shell casing, then unrolled inside so that it compresses up against the walls as shown in Figure 5.

The next step is to load the desired stars chosen for the break. These may be either cut or round stars, with cut stars being the traditional type used. The size of the stars should range between 3/8" and 1/2" regardless of the type, with 3/8" probably the most common for this size shell. Larger pumped stars may be used when making stacked comet breaks, but that is a different type of shell than described here.

Before loading the stars, a special tube known as a canulle is inserted into the center of the case to prevent stars from filling the void where the break charge will reside. The diameter of the canulle dictates the amount of burst charge that will be used. For this shell the canulle will be 1-1/4" in diameter and about 9" long (the extra length is used for making longer insert shells and not really required here). The author made a canulle by wrapping paper around a piece of 1" PVC until the proper diameter was reached, then carefully covering the paper with aluminum foil tape. This tape is to reduce the friction when removing the canulle from its tissue paper sleeve (explained below).

Due to problems with the canulle getting stuck after loading the stars around it, as well as the burst charge migrating into the gaps between the stars, a tissue paper liner is used to contain the burst charge and ease the canulle removal process. This is achieved by wrapping the canulle in two turns of tissue paper with a slight overhang at the bottom. The overhanging tissue is crimped over the end of the canulle and inserted into the center of the case (time fuse must fit inside the canulle). The size of the tissue sheet used for the sleeve is about 5" by 8" long, resulting in a 5" long sleeve.

The stars are now poured in around the canulle while it is held in place. Figure 6 shows the foil covered canulle with part of the tissue wrapped visible above half a load of round stars. Loosely fill the stars to the top of the chipboard liner, then slowly remove the canulle from the tissue sleeve. The perfectly formed central cavity is now filled with 2FA black powder for the burst charge. Fill the cavity to the level of the chipboard liner as shown in

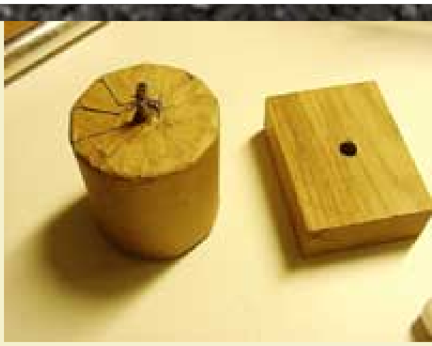

Figure 7, then crimp the remaining tissue down on top of it.

Figure 8: Shell ready for spiking.

With the burst charge loaded, the stars can now be consolidated by bouncing the casing up and down. If the shell contains chlorate stars, special care must be taken not to tamp or pound the stars, as painful accidents have occurred while tamping sensitive chlorate stars in the past. There is no need to whack the case with a stick or force the stars down with direct pressure. Simply bouncing the case should get the job done. As the stars settle, add more to fill the empty space.

Once the stars are compacted and nearly reaching the top of the chipboard liner, a rough powder known as polverone is used to fill the remaining cavity so that it is level with the top of the liner. This is simply a mix of mealpowder or green-mix with 5% dextrin that has been wetted and crudely granulated by pushing through a screen of 1/4" hardware cloth. When dry, it forms a gravel like material that is used to fill voids or top off the shell after loading the stars. The non-compressible nature of polverone, as well as the fact that it burns away with no falling debris created when the shell breaks, are the main reasons for its use.

Once the shell is solidly filled, the bottom disk is put into place and pleated in the same way the top disk was done. Since the rubber mallet can not be used to pound the paper flat this time, the bottom of the shells is pressed down against the table and rotated until it is sufficiently flattened.

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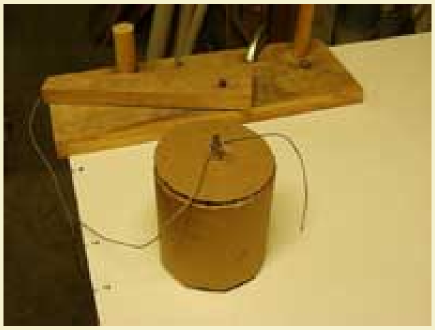

Figure 9: Flax twine tied off to time fuse.

Figure 10: Spiking is completed.

Figure 11: Pasting in the shell.

Spiking and Pasting:
Prepare the shell for the spiking process by applying another end disk to both ends of the shell using white glue to hold them in place. The internal end disk provides resistance to forces generated inside the shell, while the outer disks provide resistance to pressure applied external to the shell during lift. The paper sandwiched between them ties them in with the rest of the case, providing a very strong multi-ply end cap that will usually survive the shell burst in one piece. When building larger shells, it often becomes necessary to stack even more disks to increase the strength and avoid them getting blown in during lift.

The next step is to spike the shell with either cotton twine or a good flax twine. Flax twine is highly recommended over cotton twine due to the fact that it doesn't stretch the way cotton does when tensile stress is applied. However, the stretching resulting from the use of cotton twine can be greatly reduced by soaking it with paste prior to spiking. Paste can even be worked into the twine after it has already been spiked onto the shell prior to pasting it in. The difficulty in finding good flax twine, not to mention its steep price tag, often leaves the builder with no choice but to use the cotton twine.

For complete details of spiking theory and procedure, click this link to the spiking basics article. In addition to this article, the details for constructing a simple spiking horse can be found in this month's tool tip column. Following the directions provided in these resources should lead to the results shown in Figure 10.

With the shell tightly spiked, it is now ready for pasting. The type of paste used almost exclusively in fireworks manufacturing is made from the gluten of flour. This can be purchased as wheat paste, also known as wallpaper paste, or it can be manufactured in the kitchen by boiling a mixture of flour and water. Due to newer types of wallpaper paste, the wheat paste is becoming more difficult to find. The brand names such as Golden Harvest can also be quite a bit more expensive than using flour to make your own paste. The advantage to using wheat paste is that it can be quickly prepared in small quantities using a blender, whereas flour paste usually made in 2 quart batches. Both types of paste can not be stored and will spoil after a few days, so any amount not used goes to waste.

If you choose to make your own paste, the process is as follows: Mix one cup of flour, preferably wheat flour, into 3 cups of water using a blender. In a sauce pan, bring three cups of water to a boil, then slowly pour the mixture from the blender into the sauce pan while stirring. Continue stirring until the paste reaches a thick consistency, then remove from the heat and allow to cool. Over heating will produce thick globs of paste on the bottom of the sauce pan.

Figure 12: Pasting in over the end disks.

Mixing the paste using commercial wallpaper paste such as Golden Harvest is easiest to do by filling a blender half full of warm water, run it on high speed and slowly add the wheat paste until the paste is so thick that it no longer has a vortex in the center. The paste should be at least as thick as pancake batter, and you should be able to grab a handful of it without it running out of your hands.

Once the paste is prepared, it must be worked into the paper very thoroughly so that the paper fibers are completely saturated with paste. This process, known as "breaking" the paper, begins by coating each sheet of paper with paste on each side using the hands to smear it around. The paper is then folded like an accord ian in the long direction and crumpled with the hands to work in the paste. The long piece of crumpled, wet paper is then folded in the other direction and squeezed repeatedly. The resulting wad of saturated paper is then set aside and the process repeated for all other strips of paper required to paste the shell.

The general rule for number of paste layers for shells between three and six inches diameter is one layer per inch of diameter, thus there will be four turns of pasted paper for this shell. This results in two sheets of paper measuring 7-3/4" by 24" long, grain short. After each of these strips os broken in as explained above, they are laid flat and the shell is tightly rolled up in them. Prior to rolling the shell, some paste should be smeared all over the spiked string if the string was not previously pasted prior to spiking. The first turn of paper around the shell should be smoothed down so that it falls into the squares formed by the spiked string. The second strip is interleaved with the first and rolled the same way.

Care must be taken that the overhanging paper on each side of the shell is about equal in length. Once all the pasted strips are rolled onto the shell, the overhanging paper is ripped or cut into segments as shown in Figure 12. These strips are then pleated down similar to the way the casing was pleated onto the end disks. Some builders will simply fold all the layers over at once, but a cleaner and stronger paste job will result by folding them down one layer at a time. Any overlap at the bottom of the shell will result in a conical buildup of paper, which won't hurt the function of the shell but will increase the drying time. The strips should fold down around the base of the time fuse, building up around the base if necessary. The strips may also be ripped down the center slightly so that they can pass around the time fuse and lay flat. An alternate method is to pleat down the overhanging paper at the same time the shell is being rolled. This requires a little more skill, but can save some time when pasting many shells.

Once the pasting is complete, the shell should be dried as quickly as possible to prevent water from working its way into the inner casing. This can be done by putting the shell on a screen and placed out in the sun to dry. Using a fan to blow air across the shell will also speed up drying, and specially made dry boxes or drying rooms can be used that can completely dry the shell within a day or so. When the shell is fully dry, you should not be able to make an indentation in the paper with your fingernail.

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Figure 13: Rolling on the outer wrap.

Figure 14: Loading the lift charge.

Figure 15: Folding in the bottom.

Lifting and Leadering:

Once the shell has been allowed to fully dry, two turns of 30lb kraft are rolled around the shell in order to hold the lift charge and secure the quickmatch leader. Since the leader will transfer fire to the top of the shell, a separate piece of fuse called the passfire must be used to get the fire to the lift charge. There are a few methods for creating the passfire, and the choice of which one to use depends largely on whether you are using commercial quick match or homemade piped black match, as well as the distance from the top to the bottom of the shell. For this article, a strand of raw black match is wrapped around the time fuse and brought down the side of the case to the bottom as shown in Figure 13. The outer wrapping will serve as the "quickmatch" pipe, which works fine for a shell of this size. For larger shells, some of which won't even have a continuous wrap of kraft from top to bottom, a paper pipe would be used to sheath the passfire match. Keeping the two strands of passfire match close together, apply a few lines of white glue down the length of the outer wrap as seen in Figure 13 and roll up the shell.

The shell is now inverted and ready for adding the 2FA black powder lift charge. The amount of lift charge is determined by the weight of the shell, and is generally calculated as one ounce per pound of shell weight. This will usually be about two ounces of lift for a single color break shell of this size.

Before the lift is added, a small wad of tissue paper is used to fill the air gap around the passfire match and thus prevent the lift charge from migrating up the side of the shell during handling. The tissue wad and lift charge can be seen in place in Figure 14. The glue line applied before rolling the outer wrap will prevent lift migration around the remaining perimeter of the shell.

After the lift charge has been added, the first turn of outer wrap is pleated in over the powder as shown in Figure 15. The second turn of paper is gathered up like a paper sack and tied off with a clove hitch knot. Pleating the first turn of paper is done in order to reduce the chances of any powder leaking from the bottom of the shell.

The shell is now ready for the final step of attaching the leader. This method was developed for use with homemade black match and hand rolled match pipe, thus a different method would be needed for using commercial quickmatch. A piece of 8 strand black match is passed through a 30" segment of leader pipe and a loop is formed at the end. This loop is passed around the base of the time fuse, underneath the crossmatch, and back up into the leader pipe for about six inches. If 4 strand black match is being used, then the loop would need to double back along the full length of the leader. The pipe is pulled down so as to cinch the loop around the base of the time fuse, then the black match protruding from the other end of the leader is cut flush with the pipe.

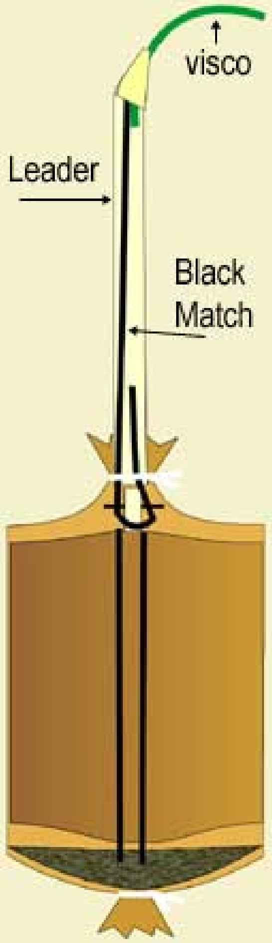

Figure 16: Details of shell leader.

The excess shell wrap is now gathered up around the leader and tied off with a clove hitch knot as shown in Figure 16. A four inch piece of visco safety fuse is inserted into the end of the leader and secured with a piece of masking tape wrapped tightly around the fuse and the leader. The use of visco is recommended over the traditional method of just extending the raw match several inches beyond the pipe, as raw match tends to burn too fast to allow the shooter to get far enough away from the shell when firing.

The long leader can now be folded over several times and secured with a band of paper for easy storage. It is also advised to roll a small tube, pinched off at one end, to use as a safety cap over the exposed piece of visco. This helps ensure against accidental ignition during handling at the firing line.

This concludes the basics of single break canister shell construction and provides the foundation for more advanced variations to be pursued once these techniques are mastered. Note that it is actually more difficult to obtain symmetrical breaks from smaller three and four inch shells than the larger sizes, and the hobbyist is encouraged to experiment with variations in break charge and spiking techniques in order to fine tune the performance of these shells.

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