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Volume 2, Issue 9

Build This...

6" 3-Break Maltese Shell w/ Bottom Shot: Part 1

Summary:
The Maltese are known the world over for their large multi-break shells, which they manufacture year around for display in several annual festivals. Construction of these large shells varies considerably from the traditional Italian methods described in most literature.

This month begins the first of a two part series that gives detailed information for constructing a typical three break Maltese shell. While this six inch shell is not considered large by Maltese standards, it is a good starting point for advanced shell builders to try their hand at Maltese style shells. The finished shell will weigh about 20 lbs and stand about 3 ft tall, making this a respectable shell for competition or any special occasion.

Perquisite Reading: Maltese Multi-break Shells

Materials:

- (8) 6" disk w/5/8" hole
- (6) 6" disk w/1-1/8" hole
- (2) 6" solid disk
- (2) 4" disk w/5/8" hole
- (2) 4" solid disk
- (4) 9" wide x 36" long strips poster board
- (2) 5" wide x 23" long strips poster board
- (4) 9-1/2" wide x 36" long 60 lb kraft
- (1) 8" wide x 34-1/2" long 60 lb kraft
- (8) 3-1/2" wide x 14-1/2" long manila folder strips
- (4) 3-1/2" wide x 6" long 30-lb kraft
- (1) 3-1/2" wide x 24" long chipboard
- (1) quart water mixed w/30g gum arabic

Tools:

- 4" case former
- 6" case former
- 1/4" dia. dowel or metal rod
- Drill press
- 5/8" spade bit or center punch
- 1-1/8" spade bit or center punch
- Thin, sharp knife with 6" blade or longer
- 4-spool/cone twine dispenser
- 1" eyelet
- 3" paint brush

- (1) half quart of 50/50 glue/water
- (1) half quart of 50/50 glue/wheat paste
- (3) cups wheat paste
- (300) grams flash powder

Unmeasured Materials:
White glue, cotton twine, sand, black match

6" 3-Break Maltese Shell, Part I...

Figure 1: Punched disks, 60lb kraft strips and poster board strips for making four 6" cans and one 4" can.

Figure 2: Paste is painted onto one side of 9.5" x 36" 60lb recycled kraft. Grain direction does not matter.

Figure 3: If a 36" strip of poster board is not possible, connect shorter pieces by overlapping.

Introduction:
The construction of Maltese shells has evolved over the years to make use of available materials while also keeping costs down. Anyone who has ever built large shells knows how much material they can consume as compared to smaller shells. The majority of shells fired at Maltese fireworks festivals are large multi-breaks, many of them eight and even ten inches in diameter!

The casings for Maltese shells are constructed quite differently than those of Italian style shells. Because their kraft paper comes from a low grade of recycled kraft used to make the paper bags concrete is shipped in, their shells are designed such that the neither the quality or the grain direction of the kraft paper matters. Instead, poster board and paste is used to reinforce the shell casing, pumped stars are used to provide horizontal integrity and a full blanket of spiking twine gives the desired burst containment.

Making the Cans:
Regardless of what size shell is being constructed, the cans for each break are constructed from two turns of 60 lb recycled kraft pasted together with two turns of a cardboard paper that is the thickness of poster board paper. Typical white poster board paper found in art supply stores works well and will be used for the shell described here.

Before you roll the cans you must first prepare the disks that will be used. The following list shows the hole size and count of the disks required for this shell:

5-1/2" dia. Disks:
(2) solid (bottom of last break)
(6) with 1-1/8" dia hole (bottom of color breaks)
(8) with 5/8" dia hole (top of all breaks)

3-1/2" dia Disks
(2) solid (bottom of salute)
(2) with 5/8" hole (top of salute)

The holes specified here are for use with a 5/8" O.D. spolette tube. If your spolettes are a different size, then you will have to adjust the hole sizes. Holes can be punched using a hammer and die set, or they can be drilled out using a drill press.

Since the cans are pasted and must dry, all cans for the shells to be built are rolled at the same time. Cans are constructed with the bottom disks in place for the color breaks, while the last bottom shot break is constructed with the top disks in place. Thus, you will make three cans using the 1-1/8" hole disks, then one can using the 5/8" hole disks.

Figure 4: Poster board overhangs the kraft half its length. Paste is applied to the poster board only where it overlaps the kraft.

Figure 1 shows all components ready for making the cans. The following strips of paper should be prepared:

60 lb recycled kraft:
(4) 9-1/2" wide x 36" long
(1) 8" wide x 34-1/2" long

Poster Board:
(4) 9" wide x 36" long (splice using 28-1/2" + 7-1/2")
(2) 5" wide x 23" long

Begin by laying out the 36" strip of kraft and applying paste to one side using a paint brush. There is no need to paste the other side or break the paper, just apply paste on one side only as seen in Figure 2.

Take the sheet of poster board (the longer sheet if two pieces are required) overlap the kraft paper such that 18" hangs over the end of the kraft, as seen in Figure 4. Apply paste only to the part of the poster board that is overlapping the kraft. If you have a second smaller piece required to get the full 36" length, overlap the first sheet by about 1/2" as shown in Figure 3. Apply paste to this smaller piece of poster board as well.

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The following sequence of steps shows how the case is constructed. The knife used in Step 2 should be very sharp and as thin as possible. The tabs should be cut quickly before the paste has a chance to seep into the poster board, which will make cutting difficult. Remember that you will be making three cans using the 1-1/8" hole disks and one can using the 5/8" hole disks.

Step 1: The poster board and kraft are rolled up onto a 5-1/2" dia case former. The edge where the kraft extends beyond the poster board should be on the flat side of the former.

Step 2: Insert a disk with a 1-1/8" dia. hole and leave about 1.5" of poster board extended. Quickly cut tabs around the edges using a thin, sharp knife.

Step 3: Separate the kraft paper from the poster board, then coat the end disk and tabs with paste.

Step 4: Fold the poster board tabs down onto the disk, then place another disk with the same sized hole on top.

Step 5: The kraft paper tabs are now pasted down over the second disk.

Step 6: Build three cans with the 1-1/8" holes, then a fourth can with the smaller spolette sized hole. Also shown is the 4" salute can.

Figure 5: The salute can gets four turns of poster board.

Making the Salute Can:
The salute can will be filled with flash and located inside a full sized break, surrounded by sand. Because burst symmetry is not an issue and this casing will not subjected to the full lift force and gas pressures, it is not constructed the same way as the main breaks.

Since the salute does need good confinement for a loud report, it is made using four turns of poster board instead of two. The case is made using two strips that will go around the former twice, which are pasted and stacked as seen in Figure 5. Again, one full turn hangs beyond the kraft, which does not get pasted on top so that the former does not get stuck to the case. The two poster board strips are also offset from each other so that the seems fall in different places.

Figure 6: A single solid disk is pleated over using only the kraft paper.

Because the poster board tabs are not required to be folded over the end disk, the kraft paper is a bit wider than the poster board. The paper is rolled up with the kraft overhanging the end of the former, then a solid disk is put in place. The overhanging paper is torn and folded down over the disk to secure it.

All cans are now set aside to dry for a few days. Accelerated drying via the use of a fan or dry-box can be used to speed up the process.

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6" 3-Break Maltese Shell, Part I...

Figure 7: Two 14.5" strips of file folder paper and a piece of 30lb kraft for rolling spolettes.

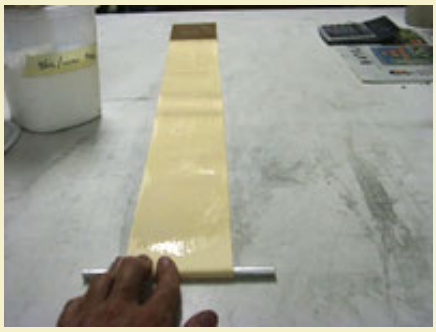

Figure 8: Strips are laid end to end and painted with a 50/50 mixture of white glue and water.

Figure 9: Finished spolette tubes ready for drying.

Making the Spolettes:
The type of tube used to make spolettes is very important. The inside diameter should be kept small, about 1/4", so that there is less surface area for the internal shell pressure to act on. The tube walls must be thick and made from strong paper in order to prevent the tube from splitting during loading. Because a lot of pressure will be acting on the powder charge when each break bursts, the powder must be rammed as hard as possible to lock it in place and prevent blow-through. Blow through occurs when the burst pressure of one break blows the spolette charge out the end of the tube and sets off the next break simultaneously, ruining the shell.

Tubes sold as "spolette tubes" by most hobby suppliers are inadequate for the job. While it is possible to find good quality spolette tubes, they can be expensive and often must be purchased in bulk quantities. For this project we will roll our own spolette tubes in a way similar to how the Maltese also make them.

An ideal paper for making spolettes is manila file folder paper. Using the legal size folders, which are 14.5" wide, cut two 3.5" wide strips for each spolette you will make (eight strips altogether). You will also need a 6" long strip of 30lb kraft that is also 3.5" wide. Figure 7 shows the paper and a 1/4" dia. aluminum rod used to roll the tube on.

Using a mixture of 50/50 white glue and water, paint the surface of the kraft strip first, then overlay a manila strip by 1/4" and fully coat it. Overlap the second manila strip by 1/4" and coat all of it except the last few inches. Begin rolling the tube from the dry end, as seen in Figure 8. If your paper is aligned straight and your rolling rod was perpendicular to the paper, you should get tubes that look like Figure 9. These should be 5/8" O.D. and fit snugly into the hole punched in your top disks. These tubes must be allowed to fully dry before loading.

The spolettes are rammed very hard with meal in several increments as if building a rocket, only there is no nozzle and the powder runs flush with one end of the tube. If your tubes came out concaved on one side, cut off a small length or sand them down to get the end level on the powder side. The other end does not need to be flush cut.

The burn time for these spolettes needs to be about 2 seconds each, and no more than that. Depending on how fast your powder is and how hard you ram it, this will be a charge of between 5/8" and 7/8". You will have to do timed trials with whatever meal you are using to determine the correct powder charge.

The Maltese do not drill back their powder cores, or even use the tapered rammer for the last increment (see spolette article). However, I find it easier to

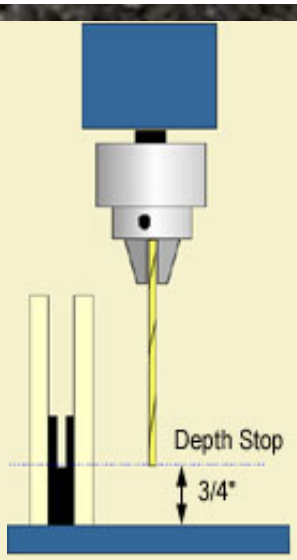

Figure 10: Using a drill press to drill back spolettes.

simply ram in three 1/4" teaspoon increments and then use a drill press with a depth-stop setting to drill through the excess comp to form a small hole that stops at the correct height of the powder core (see Figure 10). This not only achieves consistent and accurate timing across all spolettes, but also improves ignition on the passfire side. The more powder rammed into a spolette, the harder it is for burst pressure to blow through it. Thus, the drill-back method also decreases blow-through risk.

Once all the spolettes are loaded, two turns of 30 lb kraft are rolled around them so that about an inch of paper overhangs each end, as seen in Figure 11. A strip of paste is brushed down the center from end to end so that no gas can pass between the spolette tube and the paper.

Three sticks of black match are tied into the nosing paper on the passfire end, while the paper on the other end is twisted around the exposed powder core as a protective covering.

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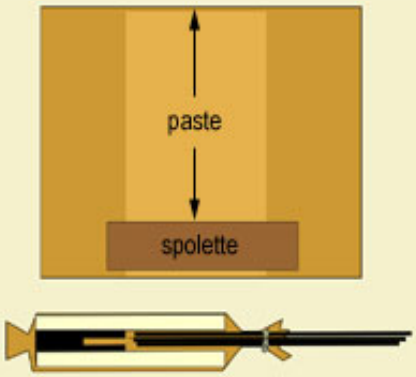

Figure 11: Rolling on the nosing paper and tied in black match.

6" 3-Break Maltese Shell, Part I...

Figure 11: Salute can with chipboard liner and sliced tabs around edges.

Figure 12: 300 grams of flash mixed with rice hulls.

Figure 13: Folding tabs down over disk.

Making the "Bomba":
The bottom shots for larger Maltese shells typically contain a smaller salute nested inside a larger shell casing. When constructing the inner "bomba" salute, the Maltese use a mixture of chlorate flash and sawdust to fill the can solid up to about 1-1/4" from the top, then they place the disk directly on top of the flash. The tabs are then cut after the disk is in place.

Since I am not comfortable mixing finely powdered aluminum with chlorates, I opt for the standard 7:3 perchlorate flash. This is diluted with rice hulls by about 1/3 in volume and the case is only filled 2/3 full. This probably does not produce as loud a report as the traditional Maltese salutes, but it is safer and uses less flash to produce.

Because I do not fill the can solid with flash, a few turns of chipboard are used to line the inside wall so that the end disk will be supported when closing the shell. I also prefer to cut the tabs before loading the flash, since I don't like the idea of any friction generating activity in the presence of flash. Insert the chipboard, put a disk over it and then cut your tabs using a sharp knife as seen in Figure 11.

Figure 12 shows the loaded case with the fused end disk being put in place. The spolette is not glued to the end disk yet, so it can slide up and down as necessary. Once in place, glue is applied around the spolette and the tabs are folded down as seen in Figure 13. A second disk will be placed over each end prior to spiking.

Steps 1-6 below show the procedure for spiking the salute. Spiking is done with four parallel strands of strong cotton twine. The tensioning mechanism is a simple yet clever technique whereby the worker actually sits on the string, using his weight to generate friction. The string passes through an eyelet in front of the worker, and may be crossed over several times to adjust the amount of force required to pull the string through the eyelet. This way the shell can be quickly wound by pulling the twine around it without having to walk or stop to unspool a spiking horse.

Step 1: Four spools or cones of cotton twine are placed behind the worker.

Step 2: Twine runs between two sheets of newspaper, which the worker sits on, then loops through an eyelet in front.

Step 3: Spiking begins by tying off around the shell itself, rather than the spolette.

Step 4: Vertical spiking is spaced at about 1/4" rather than counting any specific number of verticals.

Step 5: When the verticals are complete, the twine is run down the side to the bottom and spiked in the other direction. This horizontal spiking is also spaced at 1/4".

Step 6: Complete spiking by tying off around the shell. The twine is now completely coated with a mixture of 50/50 white glue and paste.

After the spiked shell has been thoroughly soaked with paste, it is placed on a screen to dry. When fully dried, two turns of 30 lb kraft are pasted over the shell to seal it.

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6" 3-Break Maltese Shell, Part I...

Figure 14: The 4" salute is inverted into the 6" can with the 5/8" hole, then filled around with sand..

Figure 15: A solid disk is placed over the sand, then tabs are cut and folded.

Figure 16: A second solid disk is placed on the bottom, then glue is applied around the spolette prior to spiking.

Assembling the Bottom Shot:
Rather than use the thick walled salute cores, which are used for both containment and providing vertical integrity in the bottom shots of Italian style shells, the Maltese reinforce their bottom shots by placing the salute inside a larger can and surrounding it with sand. The sand provides a non-compressible medium to withstand the lift forces without compressing and splitting the bottom break. This method is much easier and less expensive than trying to purchase or hand-roll a very thick walled tube from cardboard, which must be able to withstand the high compression forces exerted on the bottom break during lift.

Naturally the sand will add considerable weight to the shell, which is actually thought to help prevent the shell from tumbling in the air after leaving the mortar. The Maltese shell builders will sometimes cut the sand with a small percentage of sawdust to reduce the weight. When using sand mixed with sawdust, it becomes even more important to ram the sand down with a stick while loading.

The bottom shot can is the one that has the smaller 5/8" hole, which should fit snugly around the spolette of the salute. Insert the salute inside the can and push it as far as it will go. You will need at least 1.5" of spolette sticking out the top of the can, so you may have to enlarge the hole if the salute will not fit far enough down inside the can.

Sand is now poured around the salute as seen in Figure 14. Pour in a few inches of sand, then tamp it down or settle it into the can by bumping it up and down. The sand should fill above the salute to within a few inches of the top of the can, then leveled off. A solid disk is placed directly on the sand, then tabs are cut using a knife as before. The tabs are folded down as in Figure 15. Gluing the tabs is optional, since another disk will be placed on top and held down by the spiking twine.

Turn the shell upright and apply liberal amounts of glue around the spolette. Four strands of cotton spiking twine are again used to spike the shell in the same way the inner salute was spiked. In Figure 16 I have tied off to the spolette instead of around the can, which I find to be a more logical thing to do because it helps seal around the spolette seam while also aligning the string in the direction required for vertical spiking.

When the vertical spiking has been applied to roughly half the shell, it is wrapped a few turns around the spolette before continuing the rest of the way around the shell. This helps keep the tension from slipping.

The spiked shell should look like Figure 17 when finished. The string should be coated with paste prior to wrapping the shell with two turns of 30 lb kraft pasted on one side only. Since all breaks will get two turns of pasted kraft for

Figure 17: The finished bottom shot is spiked just like the inner salute was.

fireproofing, the bottom shot can be put aside and paste wrapped at the same time as the other three breaks after they are loaded and spiked.

Part II

6" 3-Break Malta Shell, Part II...

Figure 18: Cutting wooden wedges using a hammer and chisel.

Figure 19: Wedges used to lock each row of stars tightly in place.

Figure 20: Six rows of nineteen stars per break.

Loading the Breaks:
The color breaks of Maltese shells use pumped comets stacked in rings to insure vertical shell integrity, which helps prevent the shell from rupturing during lift. The comet formulas often contain dextrin, but gum arabic is also added to the binding solution to make the stars extremely hard so that they don't shatter when the shell breaks. About 30g of gum arabic per quart of water is used, which will sour upon extended storage but still remains usable nonetheless.

Loading the breaks requires lots of 3/4" comets and some wooden wedges. Rather than tamp sawdust around each comet as the Italians do, the Maltese builders wedge pieces of wood of various widths until the ring is locked in place. The wooden wedges must be cut from a piece of pine where the grain runs parallel to the thickness of the board. This means that the board has to come from the center of the tree, which is where the wider dimensions of lumber are cut from. It is easy to find a 1x10 with grain running in the proper direction, but not 1x4s or 1x5s. Figure 16 shows how a 3/4" strip cut from the edge of a 1x10 is clamped to the table with the end grain facing upwards. A chisel is then used to hammer out wedges of various random widths ranging from 1/4" to 1/8". The taper on each wedge should be minimal.

Since potassium chlorate is much cheaper in Malta than potassium perchlorate, it is used almost exclusively for both stars and flash powder. The chlorate stars are also preferred for their higher light output and shorter burn time. While US manufacturers strictly avoid allowing chlorate compounds to come in contact with sulfur containing compounds, the Maltese slurry prime their comets and stars using a mixture of black powder and gum arabic. While they have done this for many years with minimal accidents, there is still the hazard of increased sensitivity when loading shells with meal primed chlorate comets. Great care must be taken not to force the comets too hard when loading the rings, and this practice is definitely not recommended for the novice shell builder.

One trick the Maltese use to avoid having to force the comets when building the rings is to load the shell while the cans are still slightly damp after having been rolled. The comets are wedged in snugly, but not forced at all. Then as the can fully dries, it will shrink up around the comets and secure them more firmly.

The comets used for all three breaks in the shell being built in this article are Lancaster's Yellow Glitter, bound with 10% of the above mentioned water/gum arabic solution. These comets must be pressed very hard such that you can not break them or even chip pieces off of them after they dry. For more information on making pumped comets, read this article. These comets really need to be primed with meal powder to insure ignition, although they are not primed in this picture. Priming comets is best done using a star roller fitted

with temporary lift bars, made by taping dowel rods or lengths of rope to the sides of the roller drum using duct tape.

The comets used here are 3/4" diameter and 7/8" tall. It is important that every comet is the same height. Each ring will contain 19 unprimed comets, or 18 primed comets. Each break gets six rings, thus will need to pump either 324 or 342 comets, depending on if you are using a composition that needs to be primed or not. Be sure to pump a few extra for dryness testing and burn tests.

Place all 18 or 19 comets in each ring and then find wedges that fit the remaining gaps and force them in place. The last wedge should require a bit of force to insert, otherwise the ring is too lose. Comets for each successive ring should be placed between the comets of the previous ring, so that the result looks like a brick wall. Figure 16 shows one fully loaded break.

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6" 3-Break Malta Shell, Part II...

Figure 21: Plugging bottom holes with PVC plugs.

Figure 22: Filling tissue paper burst bag with 1/4" rough powder while spolette is held in place.

Figure 23: Temporary chipboard dividers used to section off three color compartments.

Before the burst core can be loaded, the hole at the bottom of the case must be plugged. Small segments of PVC with paper stuffed into one end are used for this. Since paste does not adhere to PVC, the plugs can easily be removed once the case is completed. If you can not find PVC that fits the hole tightly enough so that it doesn't fall out, wrap a few turns of newspaper around the ends until it fits tightly. This plug must remain in place from this point until the breaks are ready to be assembled.

The inner effect of all three breaks for this shell will be a triple color compartment design. The traditional method for doing this is to take a thin, hollow center tube and tape three cardboard fins that create three equally spaced compartments when inserted into the shell. The center tube is filled with burst, then each compartment is filled with a different color star. Finally the tube is carefully pulled out, taking the cardboard fins with it.

The method I use here is slightly different, due to the fact that thin metal tubes of the proper diameter are hard to find. Using PVC or paper tubes tends to present a jamming problem when you attempt to remove them, cause by stars biting into the softer material. I find it much easier to roll a burst bag using two turns of tissue around a 1-1/2" former, gluing the edge and inserting it into the center of the shell. The former is removed, leaving a thin bag to hold the burst charge.

Figure 22 shows the burst bag being filled with 1/4" rough powder. This rough powder should be made from home made meal and a good quality charcoal such as willow, paulownia or spruce. It should pass a 1/4" mesh hardware cloth and sit on top of a 1/8" hardware cloth. This is your break charge. No black powder, no flash bags, no whistle mix- just rough powder.

The spolette is centered down in the burst bag as the burst charge is poured around it. About two inches of the spolette should stick out beyond the top of the comets. This method avoids the problem of trying to push the spolette into a charged burst core when building shells from the bottom up.

Figure 23 shows the inner core of color stars filling three separate compartments. One inch wide strips of chipboard are loosely inserted to form the compartment walls. The appropriate bag of colored stars are located next to each compartment when loading the stars, which helps prevent loading the wrong color into a compartment. The 1/4" rough powder is mixed in with the stars in alternating layers. First a handful of stars is placed in each compartment, then enough rough powder to cover them, then another handful of stars etc. When the top is reached, a final layer of rough powder is used to level off the shell. The rough powder helps lock the stars in place as well as bursting the shell.

Once the shell is bumped up and down to settle the contents and leveled off

Figure 24: Rough powder used to fill in level with top of comet rings.

with more rough powder, a disk is placed over the spolette and worked down until it rests on the shell contents. Because the Maltese use chlorate stars, they add a ring of crumpled newspaper above the comets before closing the shell. Since the disk will be a tight fit, hammering with a wooden stick is often necessary to seat the disk firmly. The paper padding is a shock absorbing barrier between the chlorate stars and the impact of pounding the disk. Because we are not using chlorate stars here, the paper was omitted.

As with the bottom shot, pasted newspaper is used to seal around the spolette and the overhanging can walls are sliced into tabs and glued down. A second disk is then glued on top of the folded tabs.

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Figure 25: Pasted newspaper sealed around spolette. Glue and fold tabs as shown previously.

6" 3-Break Malta Shell, Part II...

Figure 26: A special single ply jute twine used to spike color breaks.

Figure 27: Four spools are used to apply four strands at a time.

Figure 28: Four strands are passed through spiking eyelet and tied off to spolette.

Spiking the Breaks:
Up until this point, life has been good. The cans were quickly made with no tedious pleating of paper. The breaks were loaded without going through a fortune in black powder. Pumping the comets was a drag, but other than that it has been pretty easy. Now comes the hard part.

Because these thin walled cans do not provide much containment, you have to spike the living daylights out of them. There is no counting of verticals such as when building Italian style shells. You simply spike a continuous wrap of twine until you can't see the shell anymore!

The type of twine used to spike the color breaks is very important. Cotton can not be used, nor any other type of twine that stretches. Flax is too strong, and most jute is too thick. A special single ply jute twine is required, as seen in Figure 26. This twine is quite thin, about 1/16" in diameter, and breaks with little effort when pulled. The very same twine the Maltese use on their shells is available in huge rolls from pyrosupplies.com, which is the only supplier I know of that carries it.

To keep the twine from breaking when spiking, as well as to make the process go faster, it is applied four strands at a time. Figure 27 shows four spools that sit on a dispenser behind the worker. The setup is the same one used to spike the bottom shot, where the twine runs between sheets of newspaper that the worker sits on, through an eyelet in front of the worker, and to the shell being spiked.

Steps 1 through 6 show the procedure below. Note that when starting each vertical band of twine, start from the center and progress away from the center. Once one side is complete, cross back to the center and spike from the other side as you progress away from the center again. The vertical spiking consists of four thick bands of parallel spiking that completely cover the shell.

The Maltese actually apply the vertical spiking by holding the shell with one hand and pulling the twine around it with the other. I find this method more difficult and tiring, preferring to use the Maltese salute spiking setup instead.

When applying the horizontal spiking, you may consider the use of the Maltese shell rolling tool described here. The roller supports the weight of the shell while the operator uses one hand to rotate the shell and the other hand to guide the twine.

Step 1: Vertically wrap solid, wide bands of twine on both sides of center.

Step 2: Making another wide band perpendicular to the first.

Step 3: Fill in remaining spaces with another set of intersecting bands of continuous spiking.

Step 4: Horizontal spiking is also done in one continuous twine wrap.

Step 5: Slip last horizontal wrap under a few plies of twine from atop the shell and glue the lose end.

Step 6: Applying glue/paste solution to top and bottom of spiked shell.

If you are using a weaker grade of twine, you will invariably have a strand of twine break on you at least once during this process. This usually occurs at the eyelet and is caused from snared threads or thin spots in the twine. The strand must be repaired, which is often an aggravating task.

When spiking is complete, the twine at both ends of the shell are saturated with a mixture of white glue and paste (50/50). No glue is applied to the sides of the shell, only the ends.

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Figure 29: Coating the twine with paste.

Figure 30: Rolling on two turns of pasted 30lb kraft.

Figure 31 Pleating over the ends.

Pasting in the Breaks:
Once the glue fully dries on the ends of the three breaks, they are ready to be pasted in. Begin by slathering a thick paste slurry over all the twine, including the top and bottom. The jute twine will quickly soak up the paste, making it much stronger than if the paste was not applied.

After coating the twine with paste, prepare a sheet of 30lb recycled kraft paper that is 36" long and wide enough to reach from the base of the PVC pipe to just a little past the base of the spolette. Paste one side of the kraft only, then roll up the shell. The shell should be positioned on the paper so that the bottom overlap just reaches the base of the PVC plug, while the other end is able to wrap around the base of the spolette slightly.

The paste wrap is torn and folded over the ends in the traditional manner, as seen in Figure 31. This thin recycled kraft will lay down really easily and conform tightly to the shape of the shell. Rub paste all over the outside of the wrap so that there are no dry spots. The finished breaks should look like Figure 32.

Note that this paste layer provides no shell integrity whatsoever. It is only for fireproofing the twine and sealing the shell from lift gases. Regardless of what the size of the shell is, two turns of 30lb recycled kraft is the only thing used to paste in a Maltese break. Allow the shells to fully dry before proceeding to assemble the breaks.

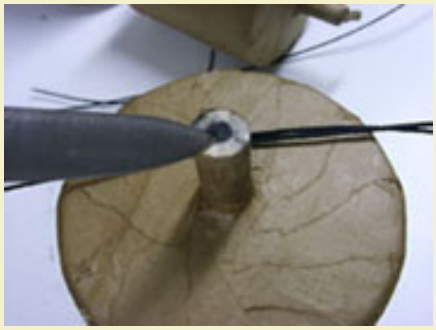
Note that each of the breaks in a Maltese multi-break shell are completed as if they were stand alone shells before being joined together. The only difference between building a single break shell and a shell used in a multi-break is that you leave a hole in the bottom of the shell for the next shell to plug into.

This "divide-and-conquer" method is much easier than the traditional Italian technique of progressively building one break on top of the previous break and applying the vertical spiking with each additional break. The stack-as-you-go method becomes too difficult and cumbersome as the shell size increases to 6" and above.

More...

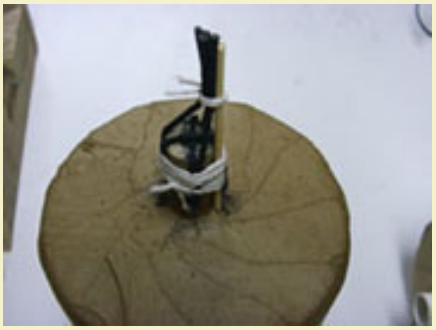
Figure 32 Pasted breaks ready for drying.

6" 3-Break Malta Shell, Part II...



Step 1: Scratching the powder surface.

Step 2: Tying on sticks of black match.



Step 3: Match is folded up and secured to bamboo skewer stick.

Figure 33 Breaks are ready for assembly.

Figure 34 Removing the PVC plugs.

Assembling the Breaks:
Once the paste wraps are dry, the shell is ready to be assembled. You will need to first prepare the spolettes of the second and third breaks, as well as the bottom shot. Tear off the paper that protects the powder core and scratch the surface with a knife as shown in Figure 1. This helps the spolette take fire easier.

Next take two 11" long strands of black match and make an X over the spolette. Use a short stick of bamboo skewer held up against the spolette so that it points straight up. The match will be tied to this to give it support when inserted into the shell above it. Fold the black match down and secure it and the wood splint with a clove hitch, then wrap twine around them several more times as seen in Figure 2.

The black match pieces are now folded back up over the twine and tied to the wooden stick. More twine is wrapped around the spolette to make sure the whole assembly does not get pulled off when the shell above it bursts.

Figure 33 shows all the shells prepared for assembly. The spolette on the top break is not matched until later. The shells will now be stacked on top of each other, starting with the first break. Invert the top break and remove the PVC plug with a pair of pliers, as seen in Figure 34. Now take the second break and push the spolette into the hole (Figure 35). The plug from the second break is removed and the third break is inserted. Finally the bottom shot is inserted in the same way.

Carefully pick up the stack of shells and lay them down onto the shell rolling jig. At this point you will need the shell press described in this month's article in order to proceed.

More...

Figure 35 Stacking the breaks upside down.

6" 3-Break Malta Shell, Part II...


Figure 36: Shell press setup over shell roller.


Figure 37: Ramming pasted newspaper between the breaks.


Figure 38 Stringing the breaks together.

Stringing the Breaks:
Once the breaks are aligned inside the press, pressure is applied to close the gaps between the breaks as much as possible. These gaps must now be filled with newspaper which is crumpled into long strips and wiped with a light coating of paste.

Start by tearing full sized sheets of newsprint in half, then crinkle each half up into a long strip. It will take two or three such strips to fill each gap. First apply a slight amount of paste by hand, drawing it across the length of the strip. The damp strip now fed into the gap between two breaks in a spiraling fashion. Use a thin wooden stick to ram the paper in place, rotating the shell as you go. Keep adding paper until it fills almost flush with the outside of the shells.

The purpose of this newspaper is to shim the shells so they do not flex at this joint. The paper also helps to fireproof the area where the shells join so that no lift gases can get into the shells and set them off during lift.

Once all three gaps have been filled with paper, the shell is ready to be strung. While it is possible to string the shell while it remains in the press, it is easier to remove the press so that it does not get in the way. The shell will not uncompress any noticeable amount, so keeping it in the press is not necessary.

Two strands of a good flax twine are used to string around all the breaks and hold them together. There will be six verticals of double stranded flax wrapped around the shell long ways. You can either use two strands at a time, or wrap around the shell twice for each vertical. Tie off to the spolette and pull the string around the shell as tight as possible. The shell is easily rotated on the rolling jig as needed. The twine is tied to the spolette again after all six verticals have been applied. Figure 38 shows the shell after the twine has been applied.

Next you will need to wrap each joint with cotton twine in order to pull the vertical strands even tighter. Four strands of cotton twine are used in parallel to reduce the amount of turns required. The twine is pulled as tightly as possible while spinning the shell on the rollers. Enough twine should be applied to completely cover the gaps between each break.

Alternate Method:
It is also possible to assemble this shell without the use of the shell press, although it is considerably more work. Starting with the separate breaks, only one break is inserted at a time, after which spiking twine is used to hold them together. Starting from the bottom up, the bottom shot and the third break are strung together first, then break two is added, followed by the first break. The newspaper is then weaved between the spiking twine and rammed into place.

Figure 39 Stringing between the breaks with cotton twine.

Figure 40 Pasting in the shell.

Figure 41 Shell ready for drying.

Note that the shell press method involves only one set of strings for the entire shell, while the manual method gives each set of breaks it's own set of string wrap. It might seem that having only one set of strings holding all the breaks together would fail after the first break broke all the strings. However, the paper in combination with the underlying string will still keep the shell from coming apart after the first break pops the twine and removes the tension it once held.

With Italian shell construction, the verticals that hold the breaks together are also the same verticals that hold the end disks on. Thus, the shell-press method shown here could not be used in the same way for making Italian style shells. The vertical twine holding the breaks together in a Maltese shell plays no role in providing confinement of the individual breaks. Each break is a separate, completed entity that would perform well if fired individually. The outer twine wrap serves only to keep the breaks held together and prevent them from flexing during handling and when being fired from the mortar. Once the shell is airborne, there is only centrifugal forces to pull the breaks apart as the shell rotates. This rotation is usually very slow and the paste wrap is more than enough to hold up against the centrifugal pulling forces.

Final Paste Wrap:
The shell is pasted in with two turns of 50 or 60 lb recycled kraft paper. A sheet wide enough to reach from a little over half the bottom to a little past the spolette is measured and cut to a length of 36 inches.

Apply paste to one side of the kraft sheet, then completely cover the shell with paste. The shell is then rolled one turn in the paper, after which time more paste is applied to the dry paper as it is pressed onto the shell. Work the paper onto the shell so that it conforms around the twine and hugs the shell tightly.

The shell is now rolled in the second turn of paper. Again the paste is applied by hand to the dry paper and worked onto the shell. The ends are ripped and pleated down in the standard method, leaving a finished shell that looks like Figure 41.

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Figure 42: Punching fuse hole in lift cup.

Figure 43: Can filled with 250 grams of 1/8" rough powder.

Figure 44: Spiking the lift can with a single strand of cotton twine.

Lift Method:
Maltese shells are lifted in a very ingenious way that, while more labor intensive to construct, has three key advantages: 1) cheap home made rough powder is used instead of black powder, 2) less lift is used than conventional methods require and 3) there is less stress on the shell, reducing the risk of rupture during lift.

Given the ever rising costs of commercial black powder, just being able to use home made rough powder alone is worth lifting shells in this method. However, consider that you can lift this 20 lb shell with only 200g of rough powder, compared with 420g of black powder required by the conventional method!

The basic idea is to contain the slower burning rough powder in a shell-like can, effectively creating a low-power black powder "salute" that sits under the shell. Above this is a plywood disk followed by a thick wad of crumpled up paper. When the lift can explodes, there is a pressure impulse that drives the plywood upward and crushes the newspaper so that it expands to seal the gap around the shell where blow-by gases normally travel. This allows nearly 100% of the lift gasses to be used to propel the shell out of the mortar. The wad of paper also acts as a cushion against the pressure impulse, preventing the shell from enduring a large pressure spike all at once. For more discussion about this lift method, read more about it here.

Making the Lift Can:
The lift can is created in the same way that all the breaks for this shell were created. A 24" long strip of 5" wide poster board is rolled along with a 5-1/4" x 24" long strip of 60 lb kraft around a 4" case former (3-1/2" actual diameter). The ends are sliced and folded down as described previously.

Once dry, the 4" can is ready to be charged. The piped match will enter the can from a hole punched in the side. The Maltese make this hole after the can is finished, but I like to pre-punch mine and cover it with a piece of masking tape. I also like to add a turn or two of chip so that the end disk can be held up off the lift charge, which creates a small void that makes it easier to insert the match later. Figure 42 shows a knife being used to punch a hole through both the 4" can and the chipboard liner.

The can is now filled with 200g of rough powder which passes through a 1/8" screen. So the particle size is between 1/8" and dust. For this shell I chose to use 250g of lift, since I want the shell to be higher up off the ground than the low level displays the Maltese desire.

A disk is inserted and tabs are sliced, folded and glued down as usual. The shell is then spiked using a single strand of cotton twine, as seen in Figure 44. Because there is no time fuse or spolette for you to tie off on when spiking the

Figure 45: Finished lift can with tapped over fuse hole.

Figure 46: Lift can, plywood disk and paper wadding in assembly order.

Figure 47: Fiber tape holding lift components in position.

Figure 48: Bending the black match over before inserting leader into lift can.

case, you just tie around the case itself and then start your vertical spiking from there. Note the high-tech spiking horse being used to provide tension while spiking (foot on string).

Once the can is complete, it can be pasted in with a few turns of 30 lb kraft, but I personally skip this step. It will work fine without the paste wrap.

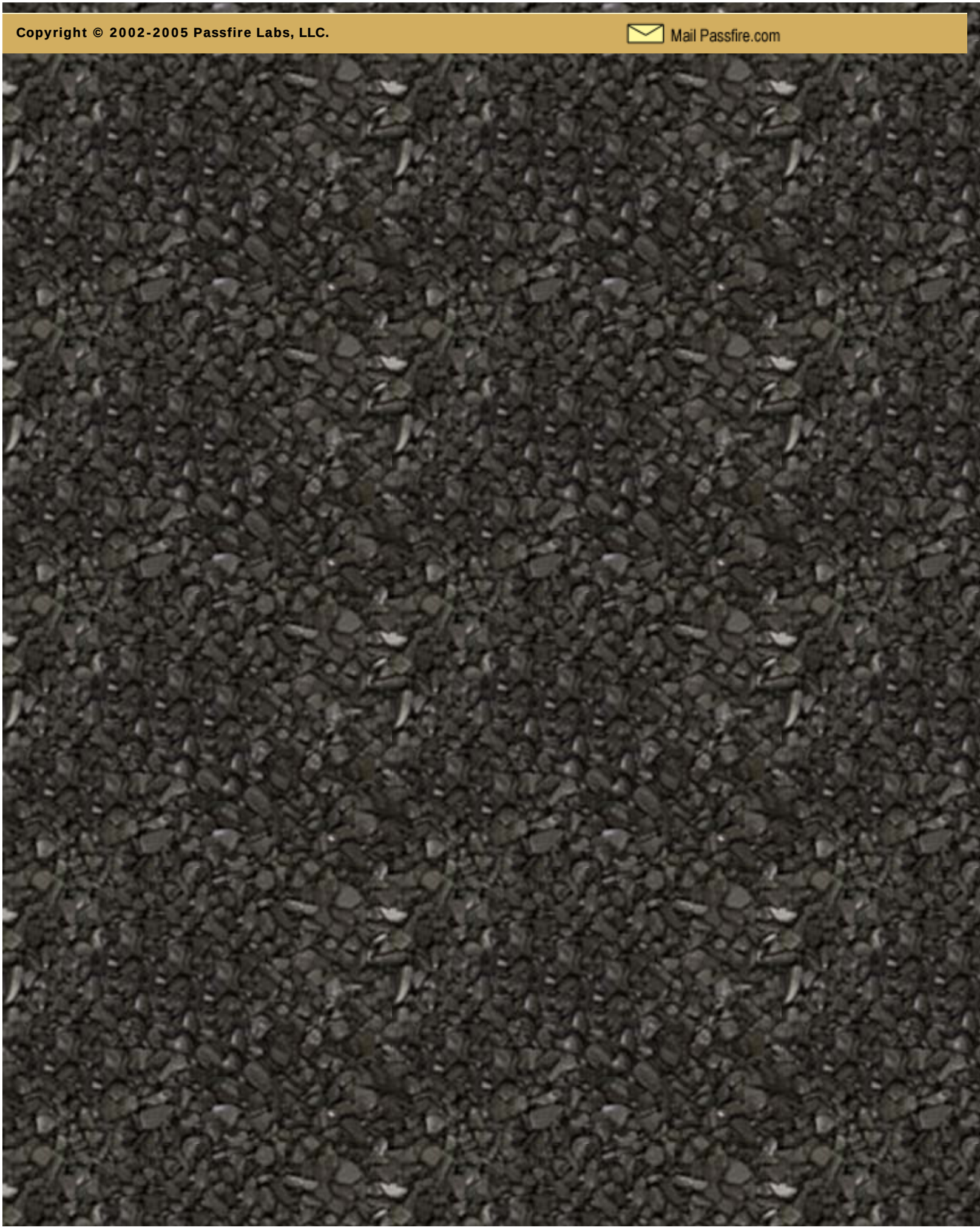
Assembly of Lift Components:
You will need to cut a 5-1/2" diameter disk out of plywood or other scrap material between 1/2" to 3/4" in thickness. Cut a small notch on the edge so that the passfire pipe has a place to route past the disk. This disk will land close to the mortar after the shell is fired and can be reused again if found.

The large wad of newspaper is made from about six full sheets of news print that are crinkled into long pieces and then rolled up like a cinnamon roll. The roll should match the outside diameter of the shell.

Figure 46 shows the assembly order for all three lift components. The shell is supported upside down and the components are securely fastened with fiber tape as seen in Figure 47. Be careful not to tape over the fuse hole in the lift can. Also make sure that the fuse hole in the lift can is aligned with the notch in the plywood disk, since that is where the passfire pipe will need to be.

The fuse hole in the lift can now be re-opened, as seen in Figure 48. Before the passfire match is inserted, the bare match should be bent into a hook as seen in Figure 48. This helps prevent it from being pulled out by accident. Push the match all the way to the center of the lift charge inside the can.

More...



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6" 3-Break Malta Shell, Part II...

Figure 49: Attaching passfire to the spolette.

Figure 50: Attaching the leader to the passfire.

Figure 51: Finish wrap at top of shell.

The passfire is routed up the side of the shell and tied off onto the spolette as seen in Figure 49. Two sticks of good quality black match should be used to insure quick and sure fire transfer. A delayed passfire can lead to the sad destruction of a lot of work, as the first break goes off in the gun and sends any surviving remains to dangerously low heights.

One little precaution I like to take is a strip of plastic packing tape applied over the entire length of the passfire, taping it to the side of the shell. This helps water proof this critical component, which can be subjected to moisture if the shell is loaded into a dirty gun that has a hygroscopic sludge buildup inside. This sludge can transfer moisture through your shell wrap and into the piped match if the shell is to remain in the mortar for any length of time.

The leader is now attached by exposing about 6" of bare match and looping it around the passfire, as seen in Figure 50. The ends are folded around and tucked back up into the match pipe, which is then slid down as far as possible.

Finish Wrap:
Whew, almost done! The shell needs to be rolled in a few turns of 30 lb kraft, which will be a sheet about 45" wide and 36" long. The kraft should overhang the top end enough to provide a good handle when lowering the shell into the gun, as seen in Figure 51. The bottom end is tongue folded and glued down as seen in Figure 52. Some builders use gummed tape or even packing tape to make an X across the bottom. I think no tape looks better and leaves less burning garbage in the mortar.

Some Maltese will tie a string around the joint between the paper wadding and the shell, which can be seen in Figure 53. I'm not sure what this is for other than perhaps to pull in any slack in the paper wrap. A second piece of string or a strip of tape is used at the top to hold the leader down until it is ready for firing.

Some Maltese builders will further decorate their shells with colored paper and bands of colored strips. It is typical to number the shells with large black numbers that indicate what order they are to be fired during the festival.

Firing Notes:
You should not attempt this shell unless you have experience with small and large caliber multi break shells. This type of shell should not be fired from HDPE mortars, as they can not handle the pressure. Use only steel guns! The suggested clearance above the shell to the top of the mortar, as recommended to minimize tumbling in the air, is about 5 inches.

Since Malta is located on a bedding of hard lime rock, it is often difficult for them to bury their steel mortars as deep as they need to be. To get around

Figure 52: Finish wrap at bottom of shell.

this problem, old tires are stacked up around the exposed length of mortar, and the operators have stone walls to hide behind.

Special Thanks to Bennie Farrugia (at right) and Paul Schembri for sharing their Maltese fireworks methods with America!

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