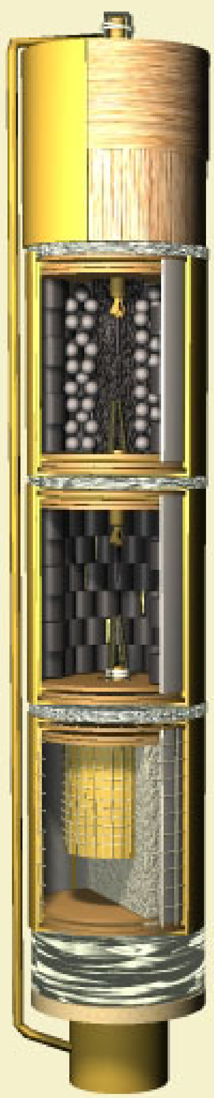
Design Notes...

Maltese Multi-break Shells

by Kyle Kepley



Introduction:

In the Fall of 2001, the Florida Pyrotechnics Arts Guild, in a partnership with the Texas FireAnts guild, brought two expert Maltese shell builders to America for a few weeks in hopes of getting a glimpse at the techniques involved in building the large multi-break shells that Malta is famous for. The idea was motivated by the successful exchange of knowledge achieved by the Crackerjacks club the previous year, where Toni Busutilli brought his intricate irdieden craft to share with Americans. Little did we know that this venture would end up being one of the best investments our guilds have ever made!

Until recent years, it has been customary for the American pyrotechnist wishing to learn more about Maltese methods of fireworks construction to make the pilgrimage to Malta to observe them making and displaying their craft. This has resulted in bits and pieces of various aspects of Maltese shell construction to be adopted by a few American shell builders over the years, although not much has been published on these methods. By bringing a few shell builders to America for a personal hands-on demonstration of building the shells from start to finish, a more complete account of basic Maltese shell construction was filmed and documented.

Fred and Lee Partin of the Florida guild worked with Bill Kimbrough of the Texas guild to bring over two well known shell builders from Malta-- Bennie Farrugia and Paul Schembri. To appreciate the sacrifice these two men made for the sake of educating us about their craft, consider that they agreed to fly overseas during the climate of insecurity immediately following the terrorist attacks of September 11. Their family made both of them sign a Last Will and Testament, with instructions to a banker to assist the family if they did not return. They then set off on a month long journey to a foreign land to meet with people they knew nothing about. This dedication to the art speaks volumes about Bennie and Paul, and we owe them a debt of gratitude for going through all this trouble to share their knowledge with us.

I was among those lucky enough to follow Bennie and Paul around for the majority of their stay in Florida, taking plenty of video and observing the whole process in person. My efforts will now be focused on getting this information out to Passfire readers in a series of articles that will appear on this website. This month will examine the basic structure of Maltese multi-break shells in general. Future articles will focus in more detail on step-by-step procedures for building specific shells, along with any tools or techniques that are required. While certain trade secrets will not be disclosed at the request of Bennie and Paul, it must be noted that these secrets are not necessary for insuring both the safety and functionality of building successful Maltese shells.

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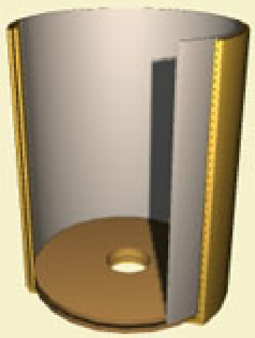

Figure 1: Pasted paper cans made from two turns of poster board and recycled kraft.

Figure 2: Comets held tightly in rings with wooden wedges.

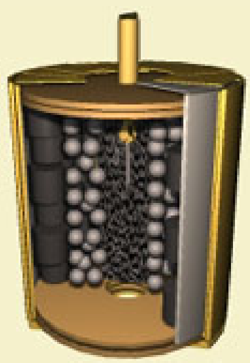

Figure 3: A fully loaded shell with 1/4" round stars and pulverone break charge.

The Breaks:

Construction of a Maltese shell begins by rolling all the cans for each break and the bottom shot required in the final shell. These cans are faster to produce and require less paper than the equivalent case of an Italian style shell. Regardless of what size shell is being produced, the cans consist of only two turns of poster board along with two turns of a 40 weight kraft paper, which can even be a cheap recycled variety! The strength is achieved by pasting the paper on one side when it is rolled, leaving a rigid can when dry. The kraft paper is pasted on one side, then the poster board strip is placed on top such that only half its length overlaps the kraft strip. The poster board is then pasted over half its length so that it will not stick to the former. The two strips are then rolled up together.

With the exception of the bottom shot cans, all cans will contain a hole in the bottom to accept the fuse from the break it will rest on top of. The bottom shot can will contain a hole exactly equal to the outside diameter of the spolettes being used. Two disks are required to make the bottoms of each can, as seen in Figure 1.

The traditional paste used for making Maltese shells is made from boiled water and flour. Upon cooling, a small amount of paris green is added to the paste in order to prevent bugs from devouring the cans in storage. The expense of paris green in recent times has led to the substitution of copper oxychloride for this purpose. The paste is typically prepared the day before it is to be used.

The disks are held in place by slicing the edges of the can with a sharp knife while still wet with paste, then pleating down the tabs over the disk while it is still on the former. The first disk is held down by only pleating the poster board layers, while the second disk is placed on top and pleated over with the remaining kraft paper tabs. These cans are fast to construct due to the minimal pleating required, especially when compared to larger sized shells constructed in the traditional Italian method.

After the cans are dried, which only takes a few days, they are loaded with rings of comet stars. Since potassium perchlorate costs about twice as much as chlorate in Malta, and since shells of this size consume a considerable weight in stars, the Maltese use all chlorate formulas for their color stars. These stars are bound with a solution containing dissolved gum arabic, which is a superior binder to dextrin and produces a stronger star that is less likely to fragment during loading and also when the shell breaks. A meal prime slurry, which also contains gum arabic as the binder, is used to prime all the stars (including the chlorate stars). Rather than ram sawdust between the comets to lock them tightly into rings, simple wooden wedges are chopped from a block and wedged into place as needed. Figure 2 shows a typical can with the comets and wedges in place.

Figure 4: Solid spiking with single ply jute twine.

Due to the sensitivity of chlorate stars to friction, great care must be taken when loading the stars and inserting the wedges. One secret to getting tight rings without using force is to load the stars the day after the cans are pasted so that paper is still damp. The stars are loaded snugly, but not wedged forcefully. When the can fully dries, it will shrink around the stars and compress them into tight rings.

Figure 3 shows an arrangement of 1/4" round stars around a central core of break charge, which would be a common configuration for a six inch break. Surprisingly, the Maltese break all their shells with pulverone made from ball milled meal powder. The pulverone used for break should pass a 1/4" hardware screen while sitting on an 1/8" screen. Everything that passes the 1/8" screen is put aside for use as lift. Thus, absolutely no commercial black powder is required for building these shells! Given the rising price of Goex in America, this feature alone makes the Maltese method worth adopting.

At this point you have a loaded shell made from a few turns of cheap recycled paper, poster board and a rough powder break charge. You are probably thinking "how is this thing ever going to have enough containment to break correctly, not to mention survive getting out of the gun?" Well, now comes the hard part.

The Maltese spiking method requires a continuous layer of a special 1-ply jute twine, both in the vertical direction and horizontally. The shell is strung with four strands at a time to help the process go faster, but it still takes longer than Italian style spiking. After applying the verticals, you should not be able to see any of the shell between the strings. The same is true of the horizontal spiking, giving a finished shell that looks like a ball of twine! Once complete, a final paste wrap of two turns 30 lb recycled kraft is used to fireproof each break.

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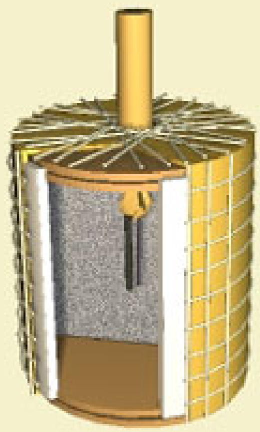

Figure 5: Inner salute casing made just like a shell.

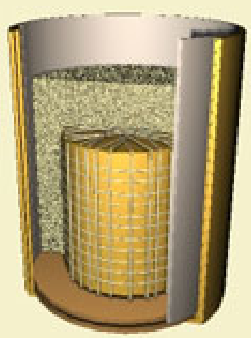

Figure 6: Constructing the bottom shot upside down.

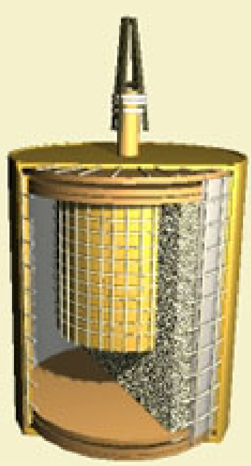

Figure 7: Finished bottom shot

The Bottom Shot:

The bottom shot consists of a smaller salute nested inside a larger can, with the empty space being filled with sand. Since most Malta shells are of a large caliber, the use of smaller insert salutes in the bottom shot is necessary to save materials and create a safer shell. Again, the high cost potassium perchlorate results in the use of chlorate based flash powder in all Maltese bottom shots.

The salute can is rolled just like the cans used for the main breaks, except only two disks are used in each end and four turns of poster board are used instead of just two. An additional four turns of 30 lb fire proofing paper is pasted around the salute after it is loaded. The salute is then spiked using four strands of cotton twine to create a flat band of twine that intersects in small squares about 1/4" on each side. Figure 5 shows the finished salute (parallel spiking strands not shown). After spiking, the string is saturated with a mixture of white glue and paste in a 50/50 ratio. This is applied using a paint brush, as the mixture is rather thin.

When the bottom shot can is rolled, the disks are fitted with holes that match the outside diameter of the spolette on the inner salute. The inner salute is inserted through the bottom of the can in an upside down position, then sand is packed around it and slightly above it.

It is said that the sand helps weigh the shell correctly in order to prevent undesirable rotation when the shell leaves the gun. I believe that the sand is also easier to load than sawdust, is cheaper, does not compress and provides more resistance when the salute breaks. These characteristics are all desirable and not produced with the use of sawdust. Due to the way these shells are lifted, the increase in shell weight through the use of sand does not pose any undesirable problems. As you will see, surprisingly little lift is required to get these large shells to the proper height.

Once the sand is loaded and packed around the salute, two disks are inserted, pleated over, then finished with a third disk on each end. The shell is now spiked with a single strand of cotton twine in the standard Italian method.

The finished bottom shot is fireproofed with two turns of 30-40 kraft just like all the other breaks, as seen in Figure 7.

Each break will be fully completed as a separate shell, then assembled by simply inserting the spolette of one into the bottom of another and stringing them together. Using a special shell press that will be described in a future article, the breaks may be squished together all at once and held with a single set of strings. Pieces of lightly pasted newspaper are rammed into the gaps between each break, which helps protect the spolette joints from accidental loaded with sand, spiked and pasted.

ignition and also serves to cushion the shells during lift.

Once all the breaks are fastened together, the entire shell is pasted in with just two turns of 60 lb recycled kraft. Note that the Maltese do not break the paper when pasting both the cans and the outer wrap. The paste is simply spread onto one side with a brush or the hands. When pasting the outer wrap, both sides of the paper get pasted.

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Figure 8: Shell, paper wadding, wooden disk and lift charge.

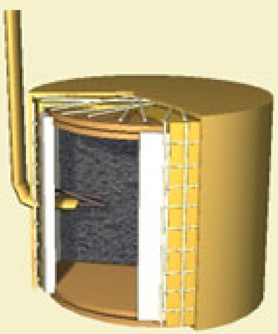

Figure 9: Lift charge constructed like a 4" shell.

The Lift:

The lift mechanism is perhaps the most ingenious aspect of Maltese shell construction. Not only does it allow rough powder to be used as the lift charge, but considerably less lift powder is required for the larger shells than when lifting with black powder. This is because almost all the gas generated by the lift charge is harnessed to lift the shell, rather than allowing some lift gas to escape as "blow-by" traveling alongside the gap between the shell and the mortar wall.

The lift powder used is simple rough powder made from ball milled meal such that it passes a 1/8" hardware screen. The powder is packed into a small 4" shell as seen in Figure 9. This lift can is constructed in the same way as all the other cans, except with two end disks instead of three. The can is then closed and spiked with one strand of cotton twine and then pasted in. This essentially creates a black powder salute, also known as a maroon. The amount of rough powder used for some common shells are shown below:

SHELL TYPE	WEIGHT	LIFT USED
4" 3-break w/bottom shot	6 lbs	180 g
4" 8-break	10 lbs	225 g
6" 3-break w/bottom shot	20 lbs	200 g
7" 3-break w/bottom shot	40 lbs	350 g
8" 3-break w/bottom shot	70 lbs	600 g

Note that these lift recommendations are for traditional Maltese shells, which have shorter timing between breaks than what is common in America. The Maltese also break their shells at a lower altitude than the commercial shells we are used to seeing and making. This results in a rapid succession of breaks that occur lower on the horizon. The lift quantities given here will have to be adjusted if higher altitudes with more drawn out timing is desired. When using this lift system there does not seem to be any rule of thumb like the "ounce per pound" rule for using black powder, so some experimentation is inevitable.

The lift can is placed under a disk made of plywood that is equal to the outside diameter of the shell to be lifted. A thick wadding of paper, known as a "sabot," is placed between the disk and the shell, and the whole assembly is held down against the bottom of the shell with either twine or tape (see Figure 8).

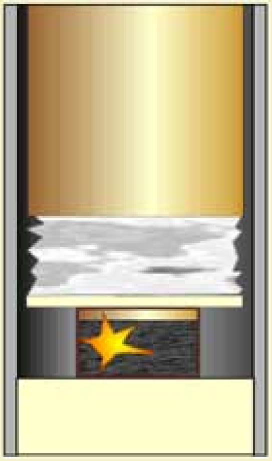

Figure 10: Pressure builds in lift charge case.

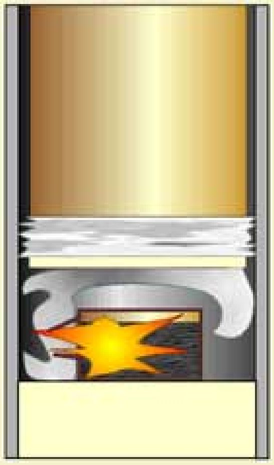

Figure 11: Case bursts, sending pressure impulse that forces wood disk upward.

Figure 12: Wood disk compresses sabot, trapping all lift gas and sending shell

upwards.

The lift sequence is shown in Figures 10 through 12. The lift can contains the pressure at first, then releases an impulse of pressure when the side bursts out. This impulse forces the wooden disk upwards and crushes the paper sabot, as seen in Figure 11. The paper wadding expands outward to form a seal around the edge of the disk, thus preventing any blow-by gasses from escaping up around the sides of the shell. This allows the full volume of gasses generated by the still burning rough powder to be used for lift. The rough powder continues to burn as the shell accelerates out of the mortar, as illustrated in Figure 12.

The sabot also provides a cushioning effect between the pressure impulse and the shell, which helps reduce stress that may otherwise rupture large shells constructed with thin walls such as these. Imagine if you took two large shells and laid them out flat on the ground, one with just a wooden disk at the end and the other with the paper cushion and then the wooden disk. Now think of the stress that would be caused if you took a large sledge hammer and struck the wood disk of both shells. The shell without the padding would likely suffer damage on impact, while the cushion of the other shell would absorb most of the force.

Although this method of lifting shells does require considerably more work than simply bagging the lift under the shell, it has the advantage of creating much less stress on the shell when fired (not to mention avoiding the use of expensive black powder). While this method would be overkill on smaller shells under a few pounds, it is ideal for heavy shells and especially long multi-break shells.

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Figure 13: Charcoal comets with AP blue inner pistil.

Figure 14: KP red comets with yellow pistil.

Figure 15: Maltese chlorate red with green pistil.

The Performance:

The series of pictures in Figures 13 through 16 show the types of breaks obtained from the Maltese shells described in this article. These shells were fired in April of 2002 at the FPAG Founders Festival in Florida and represent some of the first attempts to duplicate the shells Bennie and Paul showed us how to make.

The breaks shown here are at the optimal point of view, which is an end-view of the shell when it bursts. The shells produce very round outer rings of comets with a dense cluster of round stars at the center. The rings spread quite far in the plane perpendicular to the length of the shell, but spread very little in the other direction. This type of break, sometimes called a "pancake" break, results when a canister is made equally strong in all directions. As mathematically demonstrated by L.A. Jackson in the Reactions section of Pyrotechnica XVI, it can be shown that "in relatively thin walled cylinders under pressure, the circumferential or hoop stress induced in the walls is twice that of the longitudinal stress (in the direction of the central axis)."

Since there is not much spread in the direction of the shells central axis, the breaks will look flat if viewed on edge just as a ring shell would. However, they look quite spectacular when the angle of the shell axis to the viewer is at least 30 degrees or more.

Figure 13 and 14 are from a six inch three break shell made by myself. I did not opt to use the chlorate formulas given by Bennie and Paul, as I am not comfortable with priming chlorate stars with meal powder as it is done in Malta. This resulted in longer burning stars, yet the rings held their shape without sagging for the entire duration.

Figure 15 and 16 show an exact replica of a six inch 3-break Maltese shell built by Mitch Piatt. Note the brighter colors of the chlorate stars compared with the perchlorate stars in Figure 14. While the color tone of the KP red was in fact deeper than the chlorate stars in real life, the lower light output caused the transition to video to lose much of the red color.

These basic six inch multi-break shells are both cheaper and easier to produce than the same shell made using the Italian methods. As can be seen here, the breaks obtained are unique and quite pleasing to the eye.

As the information on Maltese shell building trickles into the hands of American pyro hobbyists, it will be exciting to see these shells appearing in club shoots and competitions across the country.

Figure 16: Maltese chlorate green comets with red pistil.

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